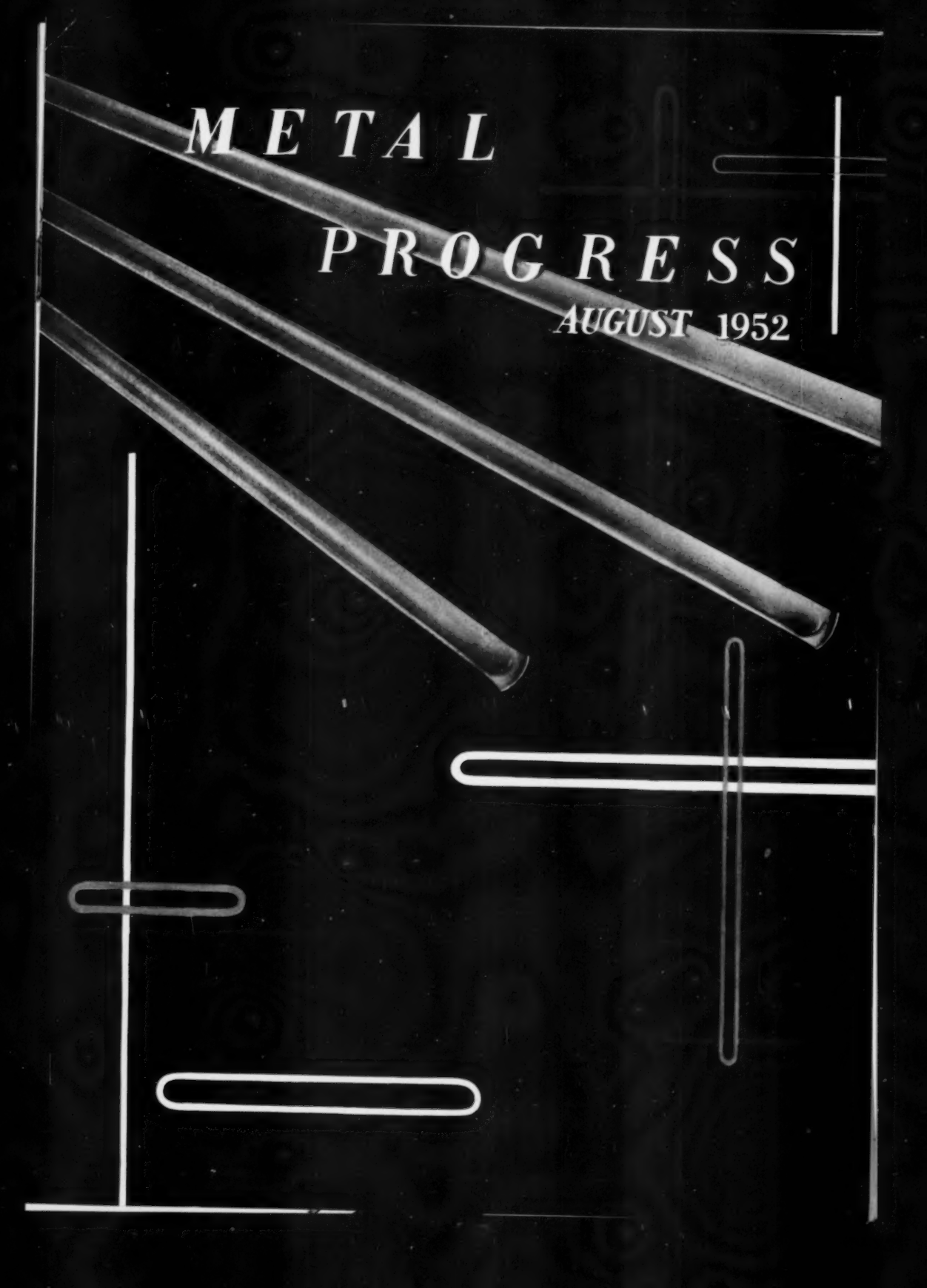
METAL
PROGRESS
AUGUST 1952

'Surface'

HEATING ALUMINUM cylinder head forgings at Tube Turns, Inc., Louisville, Ky. 'Surface' Combustion convection heated slat conveyor furnace operates at 900 F, producing 4600 lbs./hr net.

Gas-Fired furnaces for heat treating aluminum

Why use 'Surface' furnaces?

Surface Combustion developed the forced convection type of furnace, which provides maximum temperature uniformity for heat treating aluminum. Also, convection overcomes the reflective properties of aluminum, heating the charge faster and more uniformly than other types of heating. Gas-fired salt bath furnaces for the heat treatment of aluminum and aluminum alloys are also available for special applications.

If you have unusual production requirements, odd-shaped parts, particular shop practices, or space limitations, there's a 'Surface' heat treat furnace to meet your requirements.

Write today.

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'Surface' INDUSTRIAL FURNACES AND BURNERS

Kathabar HUMIDITY CONDITIONING SYSTEMS

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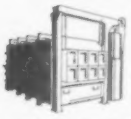
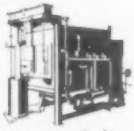
FACTORY ASSEMBLED... DELIVERED AND INSTALLED IN MINIMUM TIME



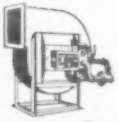
Oven Furnaces • Direct-fired. For heat treating all types of steels, as well as copper, brass, and aluminum.



Atmosphere Furnaces • Indirect heated. For heat treatment of metals where surface protection and dimensional stability are required. Furnished also in special types.

Pot Furnaces • For heating all types of metals in liquid baths. Available with either circular or rectangular pots.

Convection Furnaces • Designed for all low temperature heat treating operations on ferrous and non-ferrous alloys. Horizontal and vertical types.



Air Heaters • Direct type. For convection heating of all types of low temperature ovens.

Burners • Over 70 types and 700 sizes for all heating operations. Low pressure, high pressure, and atmosphere gas systems.

Atmosphere Generators
Forge Furnaces
Metal Melting Furnaces

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AT LONG LAST I have been given a masthead for this column. Old-timers will have no trouble interpreting it, but the 3000 new members who come into the A.S.M. each year may wonder about the Dr. Jekyll and Mr. Hyde portrayal of the author's life and experience. The sketches at the top typify the principal activities of my 34 years as secretary of "The Engineering Society of the Metals Industry". The activities depicted below represent my past 20 years as "Mr. Agriculturist" (one who makes his money in town and spends it on the farm).

At the first annual dinner of the Society in the fall of 1919 I had the honor of being master of ceremonies, and introducing such famous metal men as Dr. Howe, Dr. Sauveur, Dr. Richards and Dr. Mathews. But I must have done a job of M.C.'ing to end all M.C.'ing because I never again was asked to occupy such a position. However, I did tell a story that went around the circuit for a number of years. It was about the orator who could not remember names, so kept a list in his inside coat pocket. During one speech, after eulogizing George Washington and Abraham Lincoln, he looked in his pocket for the last time and came up with "Those three great Americans, Hart, Schaffner, and Marx".

The only other story that has survived in memory among young and old alike is suggested by the sketch in the lower line showing my educated sow who loved to ride in a wheelbarrow.

PREPRINTS—Since 1921 the Society has followed the practice of making available to members on request the preprints of technical papers presented at the annual convention. Every year we hear from some members who did not know these preprints were available in spite of the fact that some 50,000 copies are mailed annually. The list of convention papers is published in the July issue of *Metals Review* and each paper is given a number. The member should send in his order at once for the preprints in which he is interested so an advance print order may be determined by Aug. 15.

1951 WORLD METALLURGICAL CONGRESS—The first World Metallurgical Congress is a bright spot in history. In order that future generations may have an accurate and complete record of the event, an 835-page volume has just been issued and mailed to overseas conferees and to A.S.M. members and others who subscribed for this momentous work. The *Proceedings* volume contains all the addresses of welcome on behalf of industry, education and government in New York, Washington and Detroit; complete itineraries of the various groups; and more than 50 important technical articles by overseas authors. These notable papers are available only in this book.

SECOND WORLD METALLURGICAL CONGRESS—Preliminary discussions are under way for the second World Metallurgical Congress which will be held overseas in 1955 or 1956. The definite date and place will be announced immediately upon selection, so all of us may begin to save our sheckles.

I have just returned from Detroit where I received from Harper Hospital the honorary degree of M.O.I.S. (Mystic Order of the Itching Stitch) which gives me the privilege of talking about my operation to the exclusion of all other irrelevant conversation. This was my second trip to Harper Hospital and I still consider Dr. A. R. Ruedemann the magic physician of the world. He is able to make the blind see. He has restored my vision to its normal functions, so I hope to see you in Philadelphia or wherever you may be.

Sincerely,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

30% weight reduction

in heat-treat tray cuts operating costs

Weighing approximately 20 pounds less than the previous assembly, this Thermalloy heat-treat tray means the user spends less money "heating the pot" and gets more "cooking" in a working day.

Designed in Thermalloy with the help of Electro-Alloys engineers, this assembly is suited to ideal foundry practice as well as to customer service requirements. One major customer advantage is flexibility of use . . . loadings can vary from very small diameter washers and nuts up to larger requirements measuring 7½″ in diameter.

Thermalloy is not just one alloy, but a group of alloys . . . each specially adapted to certain heat and abrasion requirements. Let an Electro-Alloys engineer show you how you can cut operating costs with parts correctly engineered in the right grade of Thermalloy. Call your nearest Electro-Alloys sales office, or write Electro-Alloys Division, 2099 Taylor Street, Elyria, Ohio. *Reg. U.S. Pat. Off.

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Second, what work will you be called upon to do in the future? With L&N equipment you'll be ready to meet the most exacting quality standards. You'll find it efficient for cost-cutting. You'll find it able to take the punishment of heavy loads, quick heating and round-the-clock use. With L&N furnaces you're ready . . . for today's *and* tomorrow's heat-treating problems.

For engineered job-fitting contact either our nearest office or 4927 Stenton Ave., Phila. 44, Pa.

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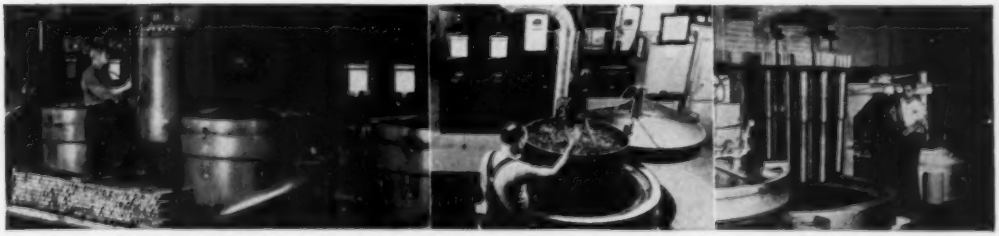
LEEDS & NORTHRUP
instruments • automatic controls • furnaces



Big production for small space with L&N furnaces is due to high ratio of net to gross load; to compact design; and to thorough insulation. Furnaces are made in sizes for every parts heat-treating need, from smallest shop to largest plant.

With dense loads (as machine-gun clips shown here) Homo's streamlined heating passages, big heaters and blowers give fast, accurate, cost-cutting production.

With bulky parts Homo Furnace vertical construction, large size and ability to hold work either racked, stacked or on fixtures give ample capacity.

Metal Progress is published and copyrighted, 1952, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.

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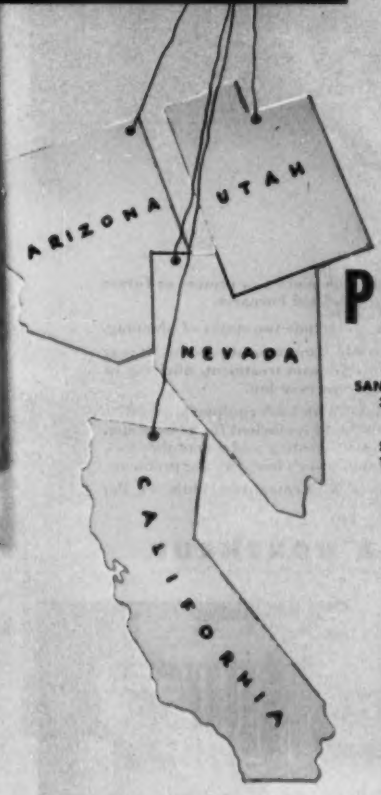

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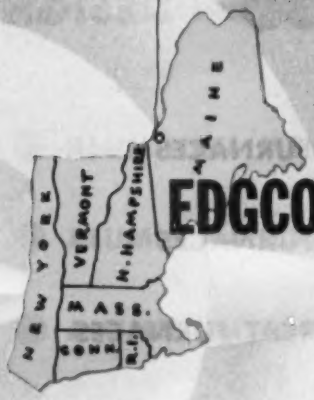

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Loftus DESIGNS
● SHELL CASE ANNEALING FURNACES (brass or steel)
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* Last year, Loftus Engineering Corporation designed and built $24 million worth of industrial furnaces. Loftus Engineering can serve you. Get in touch with us today.

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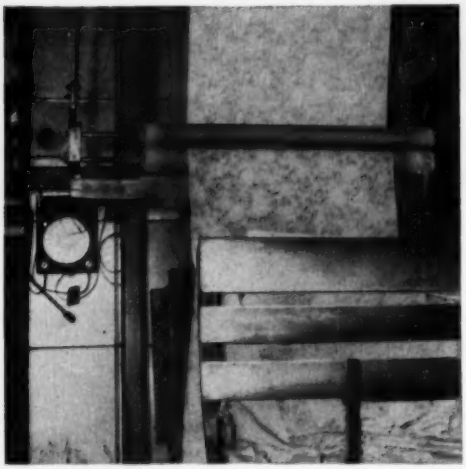
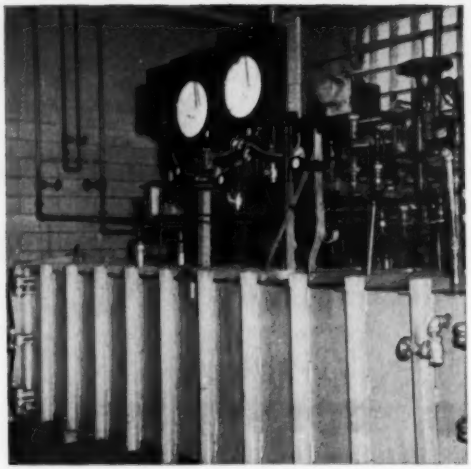


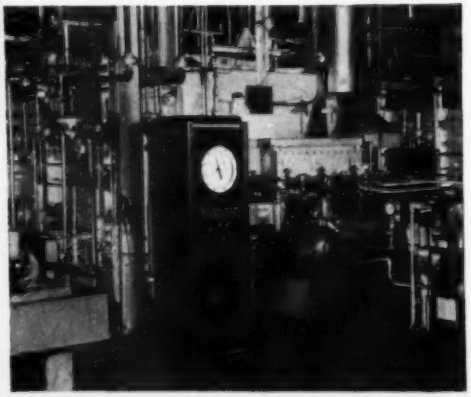
$30,000 SAVING IN ONE YEAR *was effected in this textile finishing mill . . . with the help of the Brown thermometer controlling the temperature of the print dryer. Controlled condition drying eliminated jagged fabric rips which had resulted in absolute waste.*



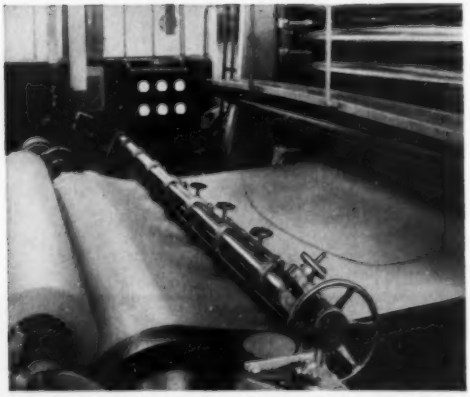
DUAL USE OF RETORT, *thanks to custom-built control system, permits using same equipment for boiling meats that is used for pressure-cooking glass-packed products. Cook time has been cut; glass breakage eliminated; labor saved; and production increased for both jobs.*

For all of industry... *especially*

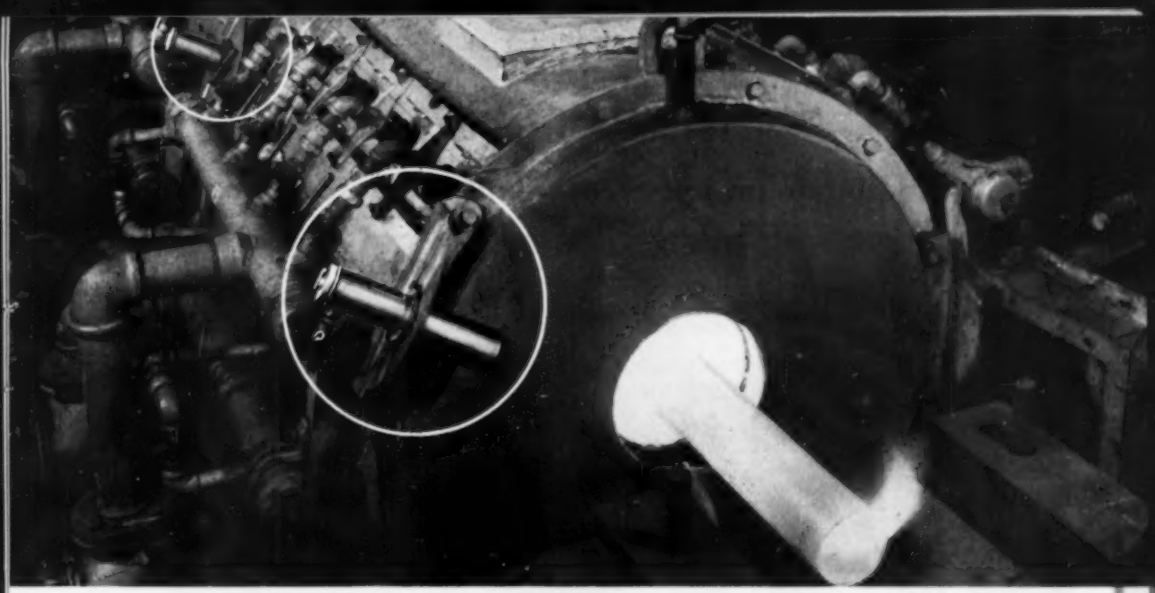
Instruments



PREVENTING COSTLY ERRORS *in heat treatment is the job of this Brown dew point recorder. Carburizing, nitriding, dry cyaniding and carbon restoration are affected by the dew point of gases employed, and have a profound effect upon the final metallurgical results.*



ALL BTU'S ACCOUNTED FOR . . . *in this machine room. Brown integrating flow recorders keep close track of every pound of steam . . . give speedy indication of excessive steam consumption. A variety of instruments hold operating costs at a minimum throughout pulp and paper mills.*



HIGH-SPEED HEATING *of seamless tubing, under accurate temperature control using* ***Radiamatic*** *pyrometers (in circles) not only saves time and cuts fuel costs . . . but also speeds production and reduces scaling.*

for the metals industries

reduce costs

RECENT YEARS have seen tremendous strides toward greater production efficiency in the metals industries . . . and in nearly every type of operation, Brown instruments contribute invaluable assistance.

They help new ore-beneficiation processes to function at top efficiency . . . and help open-hearth shops to make more steel with less fuel, and with less skull loss in ladles. On soaking pits, slab and billet furnaces and other big fuel-using equipment, their sensitive control provides accurate temperature *plus* peak fuel economy.

In metals fabrication, Brown instruments cut heat-treating costs by shortening heating-up cycles . . . and by reducing wasteful rejects. They lengthen the life of galvanizing kettles, foundry furnace refractories and melting furnace crucibles. And they aid in economical utilization of fuel, steam and electric heating power in countless other processes.

The experience of thousands of metal producing and processing plants proves that Brown instruments pay their way through reduced operating and maintenance costs . . . and with marked increases in product quality and production rates. Our local engineering representative will welcome the opportunity to discuss your specific applications, and to recommend the instrumentation best suited to your needs.

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DRAW-TEMP 430*

Well-Known Aircraft Builder Cuts Drag-Out Loss 30% With Draw-Temp Salt

To take care of a growing peak load of alloys 24S and 61S—2,000 lbs. daily—a prominent aircraft manufacturer in California recently installed two new salt baths and quench tanks. Here are the benefits obtained from the use of Houghton's Draw-Temp Salt in these furnaces: 1. Uniform temperatures obtained. 2. Time required to bring load up to temperature substantially reduced. 3. Danger of intergranular corrosion or oxidation averted. 4. A 30% reduction in drag-out losses as compared to other non-conforming salts due to high fluidity of Draw-Temp. 5. Reduced amount of salt film on work assured a faster, more uniform quench.

corrosion-free... less drag-out... faster quench...

Experience has repeatedly proved that the best method of heat treating aluminum alloys is the salt bath way, using a pure eutectic salt, DRAW-TEMP 430.

You'll avoid the bugaboo of intergranular corrosion because the pH of Draw-Temp 430 is between 6.8 and 7. That means no loss in mechanical properties because parts are free from corrosion.

You'll get a lower melting-point salt . . . more fluid . . . less drag-out . . . a faster quench because of this thinner coating of salt on the work. And you'll meet government "specs" that demand a pure, corrosion-free salt. Ask the Houghton Man!

Get Liquid Salt Bath Book—
the latest Houghton booklet covering the use of salt in heat treating, sent without cost. Address E. F. Houghton & Co., Phila. 33, Pa.

*Meets Govt. Specifications MIL-H-6088 and MIL-L-10699, Class 2

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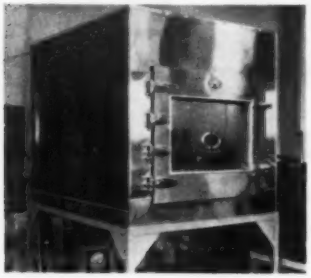
Engineering Digest

OF NEW PRODUCTS

LOW-TEMPERATURE TESTING: A recent development of the Webber Appliance Co., Inc., is a low-temperature cycling unit for heavy duty use in testing from −165 to +250° F. Inside dimensions of the test chamber are 36 by 30 by 30 in. It is equipped



with a visual port for observation during testing. In tests during development, this unit was cycled from −80 to +200° F. in 47 min. and from +200 to −80° F. in 1 hr., 45 min.

For further information circle No. 301 on literature request card on p. 32B

COPPER-SILVER ALLOY: A new high strength copper-silver bronze with high electrical conductivity is being produced by Handy & Harman. This alloy, containing 94% copper and 6% silver, is sold only in the heat treated and cold worked condition. The drastic cold working of the heat treated alloy develops tensile strengths ranging from 140,000 to 165,000 psi. and electrical conductivity of 70% International Annealed Copper Standard. It is produced in round wire 0.160 diameter down to the fine gages of magnet wire and in flat wire of equivalent cross section area having a maximum width of ½ in. Indicated applications are for spring parts requiring high electrical conductivity; also for watch and instrument parts which may be blanked from narrow strip. It shears cleanly, cuts freely to give a fine finish, and has sufficient ductility to withstand some forming operations.

For further information circle No. 302 on literature request card on p. 32B

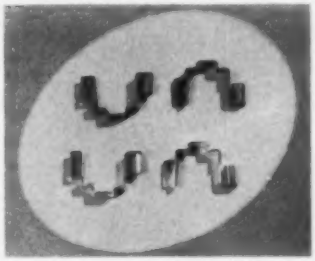
COOLANT: A new water-soluble coolant for honing has been developed by Pelron Corp. The new product, Pelron 560, facilitates the removal of stock and eliminates many problems involved in the use of kerosene and sulphur-base oils used with kerosene. Pelron 560, containing a high percentage of liquid detergent, an extreme pressure agent, and a rust preventive, eliminates excessive heat. Concentrations are 15:1 to 20:1.

For further information circle No. 303 on literature request card on p. 32B

INSPECTION METHOD: Development of a new, high-speed dye penetrant inspection process has been announced by Turco Products, Inc. The new product, called Chek-Spek, is a partner of Dy/Chek. When used in conjunction with a vapor degreaser, the process requires only two materials — penetrant (flash point, 140° F.) and developer (flash point, 180° F.). No royalty fee, licensing fee or technical service charge is made and the method is applicable to both ferrous and nonferrous metals.

For further information circle No. 304 on literature request card on p. 32B.

SOLDER STRIPPER: A new alkaline chemical for rapid dissolving of tin, lead and tin-lead solder, electrodeposits or hot dipped coatings, has been



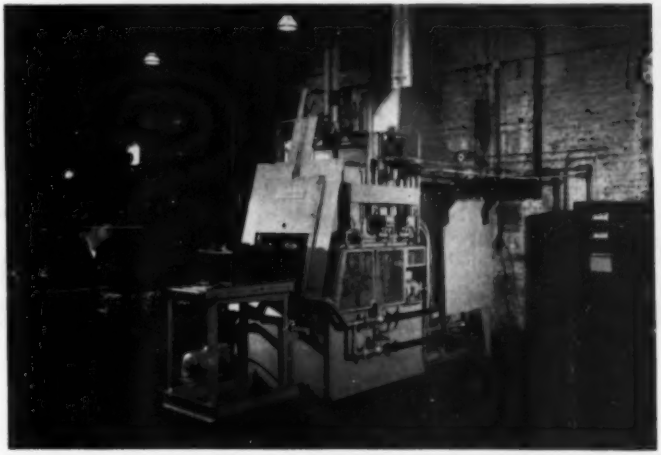
announced by Enthone, Inc. This material is used in water in a concentration of 1 lb. per gal., with the solution at 160 to 180° F. Because it is alkaline, there is no attack on copper, brass, bronze, steel and stainless steel. The stripping action on both tin and lead is fast and thicknesses of 0.005 to 0.010 in. are removed in 1 hr.

For further information circle No. 305 on literature request card on p. 32B

CLEANER FOR USE IN PHOSPHATING: A compound designed especially for use as a precleaner for steel that is to be deep drawn or extruded has been announced by the

CARBONITRIDING: The Lindberg Engineering Co. has added a new gas-fired vertical radiant-tube unit to their line of carbonitriding furnaces. The radiant tubes can be removed and replaced in a matter of minutes, eliminating costly production down time while the furnace cools. The new furnace is rated at 250 net lb. per hr. It is a completely packaged unit with built-in quench system and automatic cycle control. The endothermic atmosphere generator is adjustable to produce different atmospheres for carbonitriding, carburizing, annealing and bright hardening.

For further information circle No. 306 on literature request card on p. 32B



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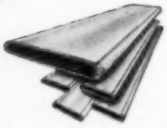
WHEREVER quality and long life count, you'll find American industry using H & H brass and copper tubing and fabricated parts. The H & H LOCKSEAM tubing in the jeep radiator at the left is widely used in automotive heating and cooling components, while the fabricated parts shown in the same illustration are typical of other H & H applications. If *your* operation calls for tubing that will *last*, call your nearest H & H representative *first*.



LOCKSEAM TUBING*

Available in round or oval shapes, in a wide range of metals. Precision cut to random or specified lengths in sizes to meet requirements of heating and cooling field. Solder coated on outside or both sides.

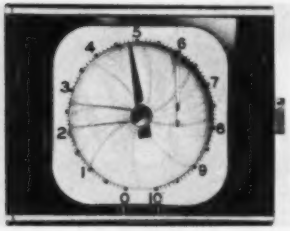
*Blueprint of size ranges and standard tubes furnished upon request.

H&H TUBE AND MANUFACTURING COMPANY
2556 North Fourteen Avenue, Detroit 17

METALFLO LOCKSEAM COIL STRIP AND SEAMLESS TUBING TUBULAR PARTS

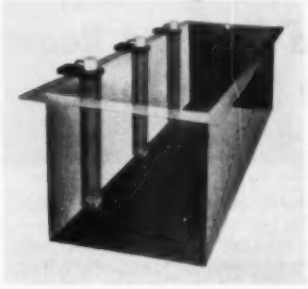
Detrex Corp. The compound, Detrex 61, is used in a soak tank at approximately 190° F. at concentrations of 6 to 10 oz. per gal. It removes oil, grease and dirt from ferrous parts.
For further information circle No. 307 on literature request card on p. 32B

RECORDER: The Bristol Co. has announced the addition of round-chart recorders and automatic controllers to its line of electronic potentiometers and bridge instruments. The new models are accurate, high-speed, continuous-balance, null-type electronic instruments which can be used to



measure any variable that can be translated into d-c current, d-c voltage, capacitance or resistance. The measured variable is simultaneously recorded on a 12-in. diameter chart and indicated on a large circular scale. Models are offered for full-scale pen travel in 7, 3, 1½, or 2/3 sec.
For further information circle No. 308 on literature request card on p. 32B

IMMERSION HEATER: The Glorod electric immersion heater, announced by Cleveland Process Co., is a fused quartz heater, inert to acids, which requires no cleaning or maintenance. As one of the best electrical insulating materials known, fused quartz



also eliminates stray currents in electroplating. Applicable for heating all electropolishing and electroplating baths as well as phosphatizing solutions, the heater is of light weight for easy handling in all metal finishing.
For further information circle No. 309 on literature request card on p. 32B

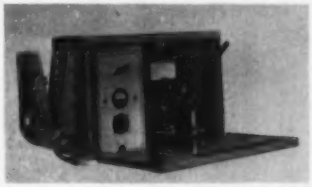
STAIN REMOVER: A new compound, Gulf No-Rust FPR (fingerprint remover), has been developed by the Gulf Oil Corp. A need for such a product is evidenced by the experience of manufacturers of parts and products with dimensional tolerances and surface smoothness of a few tenthousandths of an inch or even a few microinches, finding the product useless or inoperative because of slight corrosion or heavy staining. The new compound contains a rust preventive. It may be applied to steel, brass, copper, cadmium, magnesium, zinc, and other metal surfaces by dipping, flooding, or spraying, and can be readily removed with any petroleum solvent when the part is ready for use.
For further information circle No. 310 on literature request card on p. 32B

ELECTRIC FURNACE: The new Waltz electric furnace is equipped with a mechanical, foot-operated device for opening and closing the door, allowing the operator to use both hands for putting material in the

oven. The furnace is 220 volt, 60 cycle, and available in either single or three-phase. Heating elements are heavy chromium-nickel alloy ribbon held in grooves in the inner face of tile that acts as the inside lining.
For further information circle No. 311 on literature request card on p. 32B

FLAME FAILURE SAFEGUARD: Combustion Control Corp. has introduced flame failure safeguard type F18T-3. This new photoelectric device provides operating flame failure protection for manually ignited oil burners, air heaters, ovens and kilns, and is used with program controls to protect automatically ignited oil burner installations. On existing installations, this safeguard is readily substituted for slow-acting thermally responsive switches to give increased protection and is approved by all leading insurance laboratories.
For further information circle No. 312 on literature request card on p. 32B

SURFACE RESISTANCE INDICATOR: Weltronic Co. has announced a device to measure the surface electrical resistance, directly in microhms, as a criterion of the effectiveness of a cleaning process. It was primarily designed for measuring the resistance of aluminum; however, other materials with low surface resistance may



also be measured. It is invaluable when manufacturers must meet specifications MIL-W-6860 and MIL-W-6858 (AN-W-30 and AN-W-32). The indicator can measure directly the total surface resistance of two sheets, or coupons, when placed between two self-contained electrodes. Resistance values of 0 to 100 microhms are read directly; 100 to 1000, indirectly.
For further information circle No. 313 on literature request card on p. 32B

SAND TESTING: The Harry W. Dietert Co. has introduced an automatic unit that determines and records the permeability, green strength, green deformation and temperature of molding sand. The unit may be synchronized with conveyor belt or mixing equipment so that it will start and stop with mated equipment. It will add the correct amount of water to the sand in a mixer so that the sand is correctly tempered. The rate of testing may be selected from the fastest rate of 15 sec. per sample to one test every 6 min.
For further information circle No. 314 on literature request card on p. 32B.

PERMANENT MAGNET: A new magnetic material which exhibits a coercive force of 3000 oersteds, the highest recorded coercive force of any known permanent magnetic material, has been developed in the Naval Ordnance Laboratory. It has been named Bismanol from its composition of bismuth and manganese and NOL where it was prepared. Because of the high coercive force Bismanol exceeds any other permanent magnet except the platinum-cobalt alloy in available flux density in short magnets where the ratio of length to di-

ROTOBLAST® SAVES Over $12,000 A Year On Labor Alone

At Farrell-Cheek, this Pangborn Turn-Style Table is loaded on one side while cleaning takes place on the other. This feature alone saves the company $2159 a year on labor!

FARRELL-CHEEK STEEL CO., Sandusky, Ohio, reports:

All-Pangborn-Equipped Cleaning Room Does Better Job at Lower Cost!

New Pangborn "Blast Master" Rotoblast Barrel brings praises from foundries everywhere on outstanding new features, such as: Abrasive-Tight Door and Housing • Non-Clogging Work Conveyor • Automatic Throw-Out Torque Arm for protection against jams, etc.

Five men released for other work! That's the labor saved by modern Pangborn ROTOBLAST in the cleaning room at Farrell-Cheek Steel Co. Management here went "all-Pangborn" more than 30 years ago . . . and here's why that policy is still maintained today:

Seven ROTOBLAST Machines and a dependable Pangborn Air Blast Room clean hundreds of tons of castings each week. Production per hour has been increased . . . yet manpower requirements have been sharply reduced. Result: a $12,107 saving on labor each year!

ROTOBLAST CAN SAVE YOU MONEY, TOO! Whether you need Barrels, Tables, Rooms, or special equipment . . . Pangborn has the right ROTOBLAST equipment for every job. Write for free Bulletin 214 to: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md.

Look to Pangborn for the latest developments in Blast Cleaning and Dust Control equipment

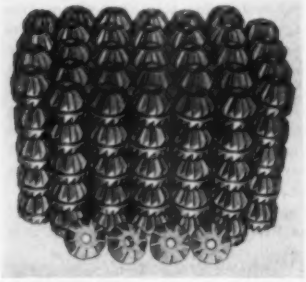
Pangborn

BLAST CLEANS CHEAPER

with the right equipment for every job

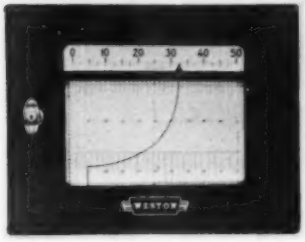
ameter is one or less. Bismanol magnets are made by powder metallurgy. **For further information circle No. 315 on literature request card on p. 32B**

HARDENING 18-8: Austenitic 18-8 stainless steel has been used for milling cutters and reamers for cutting steel and cast iron. This has been accomplished after the 18-8 tools were hardened by the new Super



Scottsonizing process developed by C. U. Scott & Son, Inc. Tools were finished to size before hardening. Large 18-8 parts, weighing up to 600 lb., have also been successfully treated by the process.
For further information circle No. 316 on literature request card on p. 32B

RECORDING POTENTIOMETER: A new recorder of the null-balancing (potentiometer) type has been announced by the Weston Electrical Instrument Corp. Among the new features is a simplified chart frame which swings out full 180° on straight pivots with the chart always remain-



ing in time sequence. A simple screwdriver adjustment provides a selection of five different chart speeds. Changing ranges requires only substituting the desired range standard on the range panel and tightening.
For further information circle No. 317 on literature request card on p. 32B

FILTER: Through use of an endless belt the Delpark industrial filter permits utilization of the same filtering mediums over and over. This filter, designed to serve individual ma-

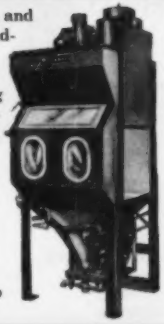
Here's BIG NEWS

Blast Cleaning Unit is PORTABLE!

Hydro-Finish SPEEDS POLISHING!

Ideal for maintenance and many other jobs, including removal of rust, dirt, scale, etc. Economically cleans large objects like tanks, bridges, structural work before painting. Six sizes, stationary or portable, from..... $170.00 and up

Removes scale, and directional grinding lines . . . prepares surfaces for plating and holds tolerances to .0001"! Liquid blast reduces costly hand cleaning and finishing of molds, dies, tools, etc. Models from $1410.00 and up

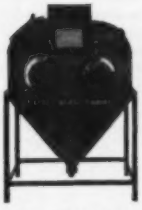


STOP DUST at the SOURCE!

COMPACT Blast Cabinet for SMALL WORK!

Pangborn industrial type Unit Dust Collectors trap dust at source. Machine wear is minimized, housekeeping and maintenance costs reduced. Solves many grinding and polishing nuisances and material losses. Models from $288.00 and up

Ideal for producing smooth, clean surfaces on pieces up to 60" x 36" in size. Cleans metal parts, removes rust, scale, grime, dirt, paint, etc., in a few seconds. Saves money all year 'round. Models from $319.00 up



Look to Pangborn for the latest developments in Blast Cleaning and Dust Control Equipment

Pangborn

MAIL COUPON FOR DETAILS

Check for more information
- ☐ Blast Cleaning Cabinets
- ☐ Blast Cleaning Machines
- ☐ Unit Dust Collectors
- ☐ Hydro-Finish Cabinets

PANGBORN CORP., 1800 Pangborn Blvd., Hagerstown, Md.
Gentlemen: Please send me more information on the equipment I've checked at the left.

Name.....
Company.....
Address.....
City.....Zone....State.....

Tempilstiks®

the amazing Crayons that tell temperatures

A simple method of controlling temperatures in:

- WELDING
- FLAME-CUTTING
- TEMPERING
- FORGING
- CASTING
- MOLDING
- DRAWING
- STRAIGHTENING
- HEAT-TREATING IN GENERAL

Also available in pellet and liquid form

It's this simple: Select the Tempilstik® for the working temperature you want. Mark your workpiece with it. When the Tempilstik® mark melts, the specified temperature has been reached.

$2 each gives up to 2000 readings

Available in these temperatures (°F)

113	263	400	950	1500
125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000

FREE —Tempil® "Basic Guide to Ferrous Metallurgy" — 16¼" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

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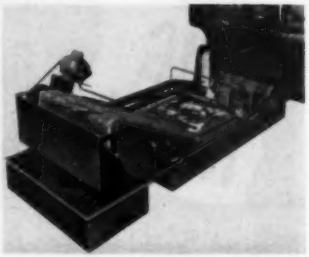
chine tools or larger central coolant systems, can also be applied to the filtering of quenching oils and washing



solvents. The filter material, in the form of endless belting, rests on and conforms to a flat endless conveyor of open construction. Capacities range from 2 to 1000 gal. per min.

For further information circle No. 318 on literature request card on p. 32B

FATIGUE MACHINE: A new model of the Baldwin-Sonntag SF-2 fatigue machine is announced by Baldwin-Lima-Hamilton Corp. The SF-2 is a standard model which now range in alternating force capacity from 25 to 10,000 lb. or from 50 to 20,000 lb. in one direction only. Maximum travel of the loading yoke is ½ in. and testing speed is 1800 cycles per min. Maximum load capacity was increased 25%. Simulated service tests of small parts can be made on the new model machine, whereas the original machine was limited to sheet metal specimens. Another feature is an accessory preload attachment which becomes a part of the machine when desired. This permits applying preload either in up or down direction. Any pulsating load may be superimposed on a static preload within the capacity of the machine.

For further information circle No. 319 on literature request card on p. 32B

FINISHING SMALL PARTS: A system which completely finishes 1440 small parts per hour has been announced by The Cincinnati Cleaning and Finishing Machinery Co. The equipment washes, phosphatizes, rinses and dries the parts, then dip paints, drains and bakes them, returning them to the loading station for unloading by the operator. The unit occupies 20-ft. square of floor space and is 10 ft. high.

For further information circle No. 320 on literature request card on p. 32B

THICKNESS TESTING: The economy, speed and convenience of nondestructive thickness measurements by the ultrasonic Audigage thickness tester can be increased by the use of a new magnetic fixture to hold the searching unit against the plate being tested. This accessory assures good contact, prevents accidental shifting of the searching unit during tests and permits one man to operate the instrument alone. It is particularly valuable when test points are beyond easy reach, such as tank bottoms and sides. The fixture consists of a flat spring with an Alnico permanent magnet coupled flexibly to each end, and means for attaching the searching unit quickly and easily to its center. The standard magnets are of sufficient strength to hold the unit properly against surfaces that are slightly irregular or covered with a thin coat of paint; heavier magnets are used on cast iron and other rough surfaces, or on plates covered with thick coatings of paint or scale.

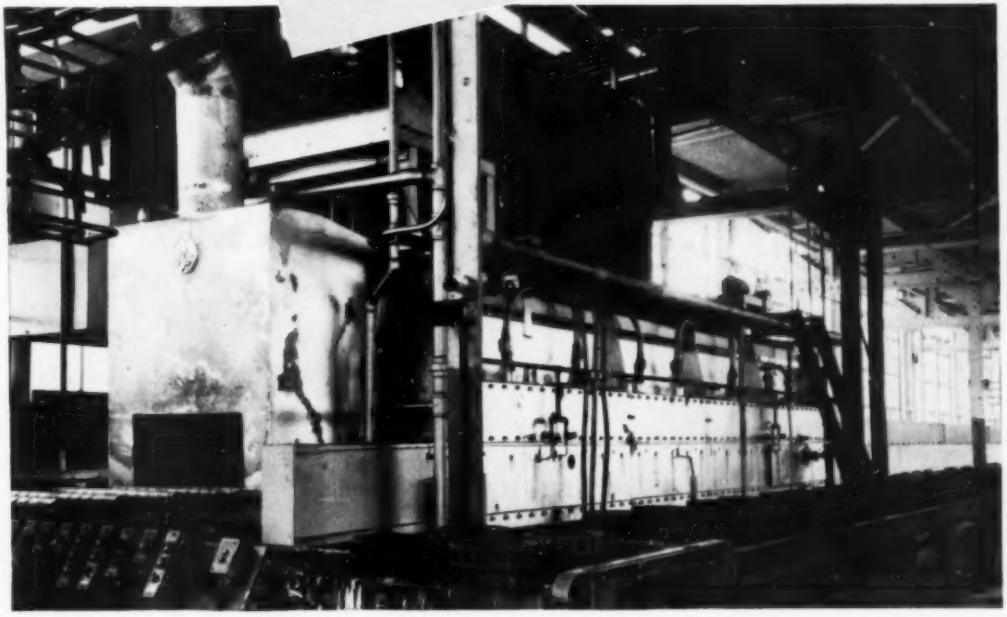
For further information circle No. 321 on literature request card on p. 32B

ABRASIVE CUTTING: Cutting by means of a high-velocity stream of gas-propelled abrasive particles, the newly developed S. S. White industrial Airbrasive unit provides a fast, accurate method of doing a number of precision operations, including controlled removal of metallized films

from glass and ceramics, drilling thin sections of hard-to-work materials, cutting extremely hard or brittle materials, etching, light deburring and polishing. In operation, a gas-propelled abrasive stream is directed against the work surface through a tungsten carbide nozzle. As it leaves the nozzle, the stream travels at approximately 1100 ft. per sec. and is only 0.018 in. in diameter. The cutting action is accomplished without increase in temperature and without the pressure and vibration experienced with other cutting methods.

For further information circle No. 322 on literature request card on p. 32B

Equipped with **GLOBAR Heating Elements** ...a sure sign of brazing efficiency



Maximum brazing efficiency, in an electric furnace, is assured through the closely controlled power input and accurate control of temperature in the heating zones. Of this, you can be certain when GLOBAR silicon carbide heating elements are incorporated into the furnace design and construction.

In roller hearth type copper brazing furnaces, such as those of a prominent automobile manufacturer shown here, additional advantages provided include a wide and flexible range of controlled temperatures... uniform heating... and safe clean operating conditions. Of equal importance, GLOBAR elements are interchangeable and can be replaced quickly and easily without shutting down the furnace.

Worth investigating are these and still more advantages of GLOBAR heating elements. Write Dept. MP 87-114 for full information.

GLOBAR
Heating Elements
by CARBORUNDUM
TRADE MARK

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company, Niagara Falls, New York.

Where steelmakers have the need, MAKERS OF ALLOYS VANCORAM CHEMICALS AND METALS *VCA shows the way.*

VANADIUM CORPORATION OF AMERICA

420 Lexington Avenue, New York 17, N. Y.
Pittsburgh • Detroit • Chicago • Cleveland

RESEARCH LABORATORY—Bridgeville, Pa.
PLANTS—Niagara Falls, N. Y., Graham, W. Va., Bridgeville, Pa.
MILLS—Durango and Naturita, Colo., White Canyon, Utah.

Here's an added source of Vancoram Alloys for the Iron, Steel, Aluminum and Chemical Industries . . .

First unit of **NEW** *plant of* **VANADIUM CORPORATION** *now in operation at Graham, W. Va.*

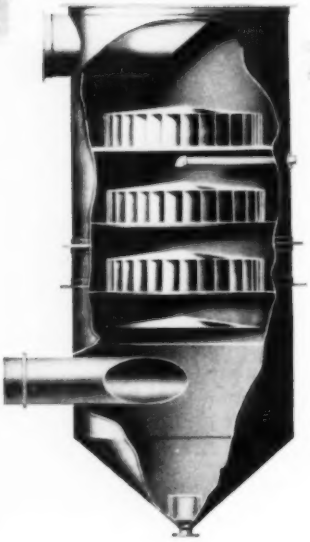
This plant is the largest single expansion in our corporation's history. Here we are producing a number of varieties of our Vancoram alloys for use by the iron, steel, aluminum and chemical industries.

Part of a consistent program of expansion, this addition is designed to keep the corporation a step ahead of the ever-growing demands of industry.

WHAT THIS PLANT MEANS TO YOU:

- Better all-round service . . . our new location is situated close to power sources, raw material supply and transportation.
- Quick deliveries . . . since output is increased.
- Easy inventory control . . . you order just the amount you need, when you need it.
- Improved production planning . . . you can count on a full supply of ferro-alloys.

Two Years without Maintenance



A dust collector of this design was constructed entirely from 14-gage HASTELLOY *alloy B sheet to resist severe corrosive conditions.*

Handling...

Hydrochloric Acid Vapors
Sulphuric Acid Mist
Nitrous Oxide
Chlorobenzol
Toluol
Aerated Benzol
Aromatic Amides

Three HASTELLOY alloy B dust collectors have just completed 2 years' steady service handling these corrosive chemicals. They are used in a large chemical plant to wash reaction gases and to reclaim many valuable chemicals.

HASTELLOY alloy B has excellent resistance to hydrochloric acid in all concentrations, even to the boiling points. It also has good resistance to sulphuric acid and many other chemicals. The alloy can be fabricated into practically any type of chemical equipment.

For information on the resistance HASTELLOY alloy B has shown to many corrosive media and on fabrication procedures, write for a copy of "HASTELLOY High-Strength, Nickel-Base, Corrosion-Resistant Alloys."

HAYNES TRADE-MARK *alloys*

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation
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Los Angeles — New York — San Francisco — Tulsa

"Haynes" and "Hastelloy" are trade-marks of Union Carbide and Carbon Corporation.

What's new IN MANUFACTURERS' LITERATURE

323. Abrasive Unit
Bulletin 5205 on small dry-abrasive airblast unit for cutting hard materials and precision metal finishing. *S. S. White Industrial Div.*

324. Air-Gas Mixer
Engineering and application data on series "LP" air-gas proportional mixer is available in Bulletin L-300. *Eclipse Fuel Engineering*

325. Alloy Steel
40-page book on heat treated alloy steel plate for maximum abrasion and impact resistance. Details on uses; 12 pp. of technical data. *Jones & Laughlin*

326. Alloy Steel
Booklet tells how 4150 and other alloy steels provide toughness, strength and durability under severe conditions of service. *U. S. Steel*

327. Alloy Steels
16-page booklet, "Alloy Steels and How to Get the Most Out of Them", contains seven case histories selected from varied fields. *Republic Steel*

328. Aluminum Bronze
12-page article, "Welding Iron-Bearing Alpha Aluminum Bronze". Test results of improved aluminum bronze alloy sheet with improved weldability. *Ampco Metal, Inc.*

329. Aluminum Castings
135-page spiral-bound book describes the aluminum casting alloys, foundry principles and practice, design considerations and heat treatment for castings; 32 pp. of tabular data. *Alcoa*

330. Aluminum Castings
24-page brochure gives tabular data on composition, mechanical properties and heat treatments of standard aluminum casting alloys. ASTM, SAE and Alcoa designations cross-referenced. *Apex Smelting Co.*

331. Aluminum Extrusion
Bulletin 340-A on aluminum extrusion process and presses of 500 to 5000 tons capacity. *Watson-Stillman*

332. Aluminum Fasteners
8-page illustrated booklet on all types of aluminum fasteners. Also accessories and screw machine products. *Alcoa*

333. Aluminum Welding
New control system that extends electrode life for spot welding aluminum, fully described in "Technical Advisor No. 15". *Reynolds Metals*

334. Ammonia for Heat Treating
20-page booklet, "Ammonia Installations for Metal Treating", gives properties of ammonia used in heat treating and describes equipment in general use. *Armour & Co.*

335. Analysis
Article on use of direct-reading spectrometer at Kaiser Steel. *Baird Assoc.*

336. Annealing
7-page article, "Annealing Steel Cartridge Cases at Ekco Products", describes furnace practice and results. *Sunbeam Corp.*

337. Anodes
Data sheet describes lead alloy anodes used for chromium plating. *United Chromium.*

338. Anodizing Racks
Folder gives data on aluminum racks with copper hooks, insulated for any anodizing solution. *National Rack Co.*

339. Anti-Carburizing Paint
Literature on paint to prevent carburizing or hardening of certain spots on steel parts. *Case Hardening Service*

340. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

343. Automatic Rockwell
Bulletin on high-speed automatic Rockwell hardness tester for quantity production. After testing, pieces are automatically sorted into good, too soft, too hard. *Testing Equipment Co.*

344. Band Saw Blades
Bulletin on wavy-set and raker-set band saw blades. Standard specifications. *Henry G. Thompson & Son*

345. Barrel Finishing
20-page bulletin on burnishing materials, finishing barrels. Six steel burnishing shapes explained. *Abbott Ball*

346. Barrel Finishing
22-page booklet J-7 gives up-to-date facts and figures on barrel finishing, tells how single-unit installation may yield savings up to 95% on various types of parts. *Almco Div.*

347. Bearing Failures
12-page bulletin 146 outlines basic steps for prevention of common babbitted bearing failures—choice of metal, pouring practice, in-service maintenance. *Federated Metals Div.*

555. Shell Molding

How important is shell molding? So important that it will replace half of all sand casting within ten years, in the opinion of one of the nation's top metallurgists. Despite its potential of 5 million tons a year, the new process has been surrounded by much secrecy, and a recent bulletin of 26 pages can reasonably claim to be the most complete and factual text available. This bulletin, "The Shell Molding Process",* will bring the technical reader up to date on principles and practice of a truly revolutionary foundry development.

The process is basically simple: ferrous or nonferrous metal is poured into backed-up resin-bonded sand shells of ⅛ to ⅜ in. thickness. Smooth as-cast surfaces are produced with dimensional tolerances of 0.002 to 0.004 in. per in. In six years of development a point has been reached where automatic mold-making machines capable of turning out 1000 shell molds an hour are on the market.

The booklet begins with a review and definition of shell molding and proceeds to an enumeration of material and equipment requirements. Under the latter, a list is given of light companies manufacturing engineered equipment for shell molding.

To make this simple foundry process work, careful control of mold materials is required. The characteristics of both ideal and satisfactory sand are discussed; information is given on sands from seven U. S. deposits. Heart of the process is the thermosetting binder, high-polymer resins produced by the plastics industry. The significance of various resin properties, for molding applications, is treated in specific terms. A discussion of practical considerations and limitations of the process completes this useful book.

*Published by Monsanto Chemical Co. Copies are available at no charge to readers of Metal Progress who circle No. 555 on the literature request card, page 32B.

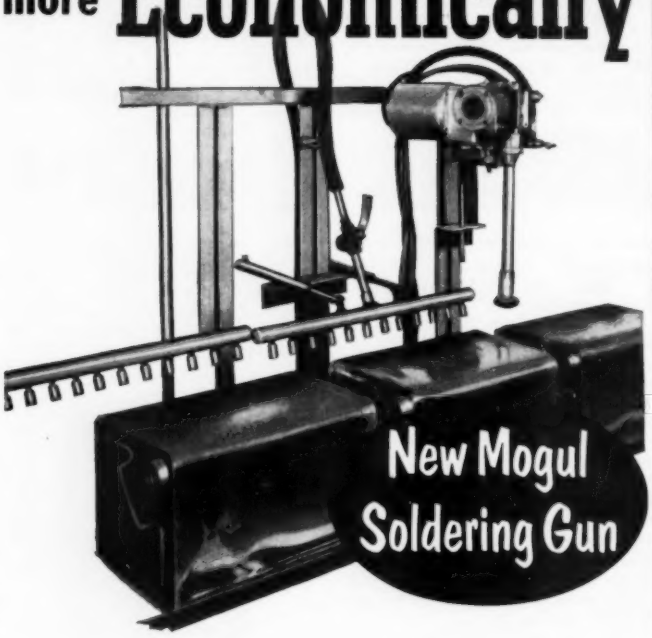
341. Atmospheres
Bulletin 1-10 supplies technical information on inert gas generators and data on costs. *C. M. Kemp Mfg.*

342. Automatic Polishing
14-page, illustrated brochure describes automatic equipment for polishing, buffing and grinding. *Murray-Way*

348. Bending Aluminum
Bending formulas and radii for 90 and 180° cold bending of various grades and tempers of aluminum. From "Technical Advisor No. 18". *Reynolds Metals*

349. Bimetal Elements
32-page booklet, "Successful Applications of Thermostatic Bimetal", describes 18 uses and gives engineering data. *W. M. Chace Co.*

production Soldering
BETTER JOBS FASTER
more Economically



Big labor saving
Solder saving
Increased production
Pin-point location for cleaner seams
Better work appearance
Adjustable to the speed of work
Lower maintenance cost

This new MOGUL unit is built to deposit silver, lead and tin base solders in a liquid or semi-liquid form . . . faster, cleaner . . . to any constant moving part. This new automatic gun replaces the soldering bath, hand soldering, and in many cases, expensive fixtures. Quickly adapted to various size parts.

Deposits solder or brazing wire to the exact spot for cleaner seams. This new MOGUL soldering gun is now in wide use, saving time and money, increasing production, and turning out a better-looking product.

Write today for new MOGUL SOLDERING GUN bulletin.

MOGUL

METALLIZING COMPANY OF AMERICA

Dept. MP, 3520 West Carroll Avenue
Chicago 24, Illinois
Telephone: SAcramento 2-3710

350. Blackening Compounds
Bulletin on blackening compounds (for ferrous alloys) to AMS Spec. 2485. *Swift Industrial Chemical Co.*

351. Blast Cleaning
New 4-page brochure explains a completely enclosed chamber in which large castings are cleaned by streams of centrifugally hurled abrasives. *Pangborn*

352. Blowers
Bulletin on new constant-pressure turbo blower and properly selected piping. *North American Mfg.*

353. Boiler Tubes
Bulletin TB-331A gives working pressures and other data on boiler tubes. *Babcock & Wilcox*

354. Brass and Bronze
8-page booklet on control methods applied to brass rod, forgings, die castings and welding rod. *Titan Metal*

355. Brazing
Bulletin 124 — on salt bath brazing process — shows how it is possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies. *Ajax Electric Co.*

356. Brazing
50-page text GEA-3193 describes the methods and applications of electric-furnace brazing. *General Electric*

357. Brazing Stainless Steel
Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel", describes conveyor furnace and bright brazing alloy. *Sargeant & Wilbur*

358. Brazing Washers
Free sample of silver brazing alloy preformed washer coined from wire. *Lucas-Milhaupt Engineering Co.*

359. Bronze Castings
Booklet on sand and centrifugal castings. *American Non-Gran Bronze*

360. Burners
Bulletin 1000 on multiport flame-type gas burners for use in brazing, soldering, hardening and tempering. *Selas*

361. Burners
Bulletin on combination gas and oil burner with high rate of combustion. *Ra-Diant Heat Refractories Sales Co.*

362. Burners
Bulletin 1220-5 describes tempered flame burners for controlled heating and cooling cycles. *Bloom Engineering*

363. Carburizing
Case history and job data on localized carburizing of sewing machine parts. *Ipsen Industries*

364. Carburizing Baths
Bulletin contains charts of relative case penetrations at various times and temperatures. Also replenishment chart for salt baths. *A. F. Holden Co.*

365. Castings, Heat Resistant
Bulletin on heat resistant castings for conveyors, roller hearths, trays, and tube assemblies. *Standard Alloy Co.*

366. Ceramic Coating
24-page book on ceramic coating as a means of conserving strategic metals and extending metal life at high temperatures. *Solar Aircraft*

367. Cleaner
Bulletins on Virgo descaling salt and Virgo molten cleaners. What they are, how they work, their advantages and how they fit into your operations. *Hooker Electrochemical Co.*

368. Cleaner
Folder gives data on industrial metal cleaners for use with water in either still-tank or spray-washing equipment. *Solventol Chemical Products*

369. Cleaning
Bulletin 30 describes dip method of precleaning metal. *Magnus Chemical*

370. Cleaning
12-page bulletin on washing and drying machines; conveyor, cabinet, drum and vertical types described. *Industrial Washing Machine*

371. Cleaning
Bulletin 214 gives full details, specifications and actual performance on Rotoblast cleaning. *Pangborn*

372. Cleaning
Catalog describes selection and use of shot and grit for cleaning and peening. *Cleveland Metal Abrasive Co.*

373. Cleaning and Buffing
24-page booklet describes origin and development of various metal cleaners and tripoli compositions. *Puritan Mfg.*

374. Cleaning and Finishing
16-page brochure on various cleaning processes, phosphating, aluminum brighteners and rust preventives. Reference chart included on six phosphating cycles. *Turco Products*

375. Cleaning and Finishing
12-page illustrated catalog A-652 gives the complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines operating in large metalworking plants. *R. C. Mahon Co.*

376. Coatings and Packaging
43-page guide to better preservation and packaging deals with procedures for hot dip packaging. *Seal-Peel*

377. Coatings, Metal
Explanations of high-vacuum evaporation of metals and other solids set forth in detail in new 12-page booklet, "Vaporized Metal Coatings by High Vacuum". *Distillation Products, Inc.*

378. Cobalt Alloy
12-page booklet, "Haynes Alloy No. 25", tells of the unique properties of this cobalt-base alloy. *Haynes Stellite*

379. Cold Extrusion
Folder describes process in which 5-in. dia. steel billet can be cold formed to a cup with less than ¼ in. wall thickness in three strikes. *Detrex Corp.*

380. Combustion Equipment
Catalog 52 gives condensed pictorial review of oil and gas combustion equipment for production applications. 80 illustrations. *Hauck Mfg.*

381. Composite Castings
16-page brochure illustrates 50 applications of casting process for making bi-metallic components. *Al-Fin Div.*

382. Continuous Castings
12-page catalog describes properties, sizes and weights of continuous cast bronzes. *American Smelting & Refining*

383. Controlled Atmospheres
24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Letrodryer*

384. Coolant System
Bulletin on new atomizing system to aid cooling and lubricating of cutting tools. *Henry G. Thompson & Son*

385. Copper Alloy Tubes
Extensively illustrated 32-page brochure deals with causes of corrosion and means of combating them, as well as choice of materials for condenser tubes. *Revere Copper & Brass*

386. Copper Alloys
Article on refining secondary copper alloys deals with sequence of removal of Al, Mn, Si, P, Fe, Zn, and use of pure oxygen instead of air. *R. Lavin & Sons*

387. Corrosion-Proof Cement
12-page bulletin gives corrosion resistance of four types of cement versus 176 common chemical solutions. *Atlas Mineral Products*

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388. Corrosion Resistance
Corrosion data on Koroseal tank linings in contact with plating baths and other corrosive solutions. *Metalweld*

389. Corrosion Resistance
Single-page technical discussion of factors affecting corrosion resistance of stainless steels. *Cooper Alloy Foundry*

390. Cut-Off Machines
16-page bulletin gives facts and figures to aid in selection of the right cut-off machine for a given job. 14 models described. *Tabor Mfg.*

391. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

392. Cutting Compounds
Data on cutting compounds for stainless and titanium. *Hangsterfer's Labs.*

393. Cutting Oil
Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service Oil*

394. Cutting Oil
32-page bulletin of case histories on use of all-purpose base in various machining operations. *Houghton & Co.*

395. Cutting Scrap
Information available on oxygen-cutting and powder-cutting with Oxweld equipment to rapidly convert any steel or cast iron section into good, usable scrap. *Linde Air Products*

396. Definitions
36-page glossary of over 150 terms for producers and users of cast iron. *International Nickel*

397. Demineralizer
Bulletin on ion-exchange demineralizer for low-cost purification of water for plating and other uses. *Industrial Filter & Pump*

398. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. Treating cycle, chemistry of bath, raw materials and equipment design. *Du Pont*

399. Die-Casting Machines
Illustrated booklet giving specifications, application data and full explanations of two new production advantages on company's line of die-casting machines. *Lake Erie Engineering*

400. Die Casting
4-page folder describes four die-casting lubricants developed to provide clean, accurate castings, longer die life and more economical production. *E. F. Houghton & Co.*

401. Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

402. Die Steel
Composition, properties and treatment of water-hardening alloy steel for cold heading dies, for life two to four times greater than formerly available. *Allegheny Ludlum Steel*

403. Die Steel
Bulletin shows comparison of wear resistance, toughness and size rigidity for five grades of high-carbon, high-chromium die steels. Also curves of impact and hardness versus tempering temperature. *Latrobe Steel*

404. Drawing Compounds
Folder describes new type of lubricant for cold forming and drawing of stainless steel, both austenitic and ferritic. *Hangsterfer's Laboratories*

405. Drawing Zinc
Folder gives examples of drawn zinc articles. *American Zinc Institute*

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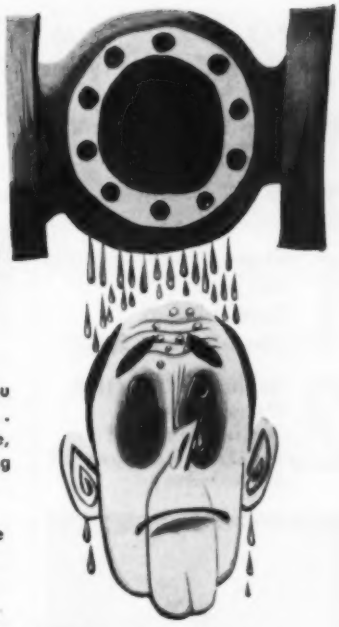

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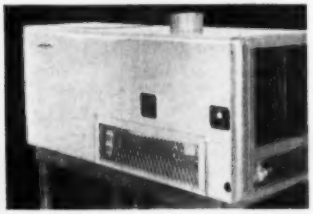

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For years the protection of combustion chambers and outer coverings of heating equipment has been a problem.

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SICON protects their combustion chambers against extreme high heats of 875° without powdering or losing its color.

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406. Ductile Iron

Bulletin compares ductile iron with gray iron, malleable iron and cast steel. Eight examples of applications where ductile iron is profitably employed. *American Brake Shoe*

407. Electric Contacts

12-page catalog on properties and uses of electrical contacts. Included are silver, palladium, nickel and powdered metals. *Gibson Electric*

408. Electric Furnaces

Bulletin 473 describes rocking, automatic melting machine for various ferrous and nonferrous alloys. *Detroit Electric Furnace Div.*

409. Electric Thermometers

Catalog 6482 on recording circular-case electric thermometers for temperature control of ovens and plating tanks. *Minneapolis-Honeywell*

410. Electroforming

6-page reprint compares uses and production of electroformed articles from copper, iron and nickel. *International Nickel*

411. Electromagnet

Bulletin on multipurpose density for metal research. *Arthur D. Little, Inc.*

412. Electron Microscope

New 20-page brochure describes in detail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

413. Extrusions

Data on services in the field of aluminum extrusions. *Himmel Bros. Co.*

414. Finishes

4-page folder about Iridite gives the characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research Products*

415. Finishing

Series of six bulletins describing finishing compounds for stainless steel, aluminum and other metals. *Apothecaries Hall*

416. Finishing

Check list on sixty products and processes for metal finishing, including an acid addition agent, a cleaning and pickling agent combined, a complete inhibitor and rust-preventive compound. *Enthone*

417. Finishing

Folder describes equipment for barrel plating with unique contact arrangement for maximum current distribution. *Daniels Plating Barrel & Supply*

418. Finishing Systems

Bulletin No. 501 on complete finishing systems, cleaning and rust proofing equipment, spray booths and drying ovens. *Peters Dalton*

419. Fire Checks

12-page Bulletin 1006 describes two protective devices to control flashback in combustion equipment. *Selas*

420. Flame Hardening

4-page illustrated folder features new giant-size flame hardener at company which can flame harden forgings 4 to 18 in. in diameter, up to 20 ft. long. *National Forge & Ordnance*

421. Flaw Detection

Information on electronic equipment for nondestructive inspection of regular and irregular iron and steel parts. *Magnetic Analysis Corp. (Foerster)*

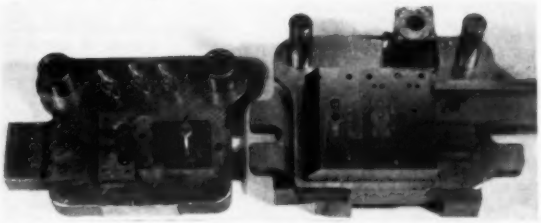
422. Flow Meter

Bulletin 52-1017-37 on gas flow meter for furnace installations. *Hays Corp.*

423. Flow Meters

Catalog C-12 describes meters and accessories for measuring pressure, vacuum and differential pressure of liquids and gases. *Meriam Instrument*

350,000 Wing Nuts from Ziv's Hargus Tool Steel Die...



This progressive pierce-blank-form die is ZIV'S HARGUS tool steel. From it were made 350,000 wing nuts with a production per grind of 87,500 pieces. HARGUS, an oil-hardening, non-deforming tool steel, was selected, in preference to other types of steels, for this intricate die because past experience with HARGUS had convinced the user that he could rely on its serviceability. The die shown costs approximately $800.00. Yours may be more or less expensive. In any case, it will pay you to use HARGUS.

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424. Flow Meters

12-page catalog 40 describes variable-area floor meters having precise tapered metal metering tubes and designed for both high temperature and high pressure. *Fischer & Porter Co.*

425. Forging Steel

Bulletin 31 on stainless forging problems includes data on steels. *Timken*

426. Forgings

New booklet on smooth hammered forgings of alloy, stainless and tool steel. *Allegheny Ludlum*

427. Forgings

8-page Bulletin No. 5201 describes production facilities for engineering, planning, production, heat treating and machining of forgings, and for punching, welding, riveting, assembly and painting. *Pittsburgh Forgings*

428. Formed Parts

20-page brochure describes company's facilities for fabricating components from metal wire, strip and other materials. Precision blanking, drawing, forming, wiredrawing and welding. *Parts Div., Sylvania Electric*

429. Forming

Bulletin on spinning, stamping and fabricating facilities. *C. A. Dahlin Co.*

430. Forming

32-page brochure describes universal contour former which combines stretch, compression, and radial-draw forming. Over 100 photos show applications to extrusions, tubing, sheet, and rolled and formed shapes. *Cyril Bath Co.*

431. Forming Magnesium

7-page article covers bending, spinning, stretch forming, deep drawing and other processes for magnesium sheet. From "Magazine of Magnesium". *Brooks & Perkins, Inc.*

432. Free-Machining Die Steel

Bulletin on properties, heat treatment and application of free-machining steel for die-casting dies and plastic molds. Hardenability and temperability curves. *Vanadium-Alloys Steel*

433. Furnace Controls

Instruments and controls for heat treating furnaces are described in bulletin 51-750-51. *Hays Corp.*

434. Furnace Fixtures

Baskets designed for individual needs in handling parts. All types of trays, fixtures, retorts and carburizing boxes are described. *Stanwood Corp.*

435. Furnaces

Bulletin on gas, oil and electric furnaces of box and pot types for heat treating. *Dempsey Industrial Furnace*

436. Furnaces

Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

437. Furnaces

16-page booklet "Proven Heat Treating Efficiency" containing attractive four-color illustrations displays complete line of furnaces. *Loftus Eng'g.*

438. Furnaces

Bulletin HD-850 describes new shaker hearth furnace for bright carburizing, bright dry cyaniding or bright hardening of small parts up to 150 lb. per hr. *Hevi Duty Electric*

439. Furnaces

12-page bulletin describes chain belt conveyor furnace, radiant tube gas heated, oil or electrically heated. *The Electric Furnace Co.*

440. Furnaces

Bulletin on furnaces for annealing, normalizing, hardening, tempering, forging. *Flinn & Dreffein Engineering*

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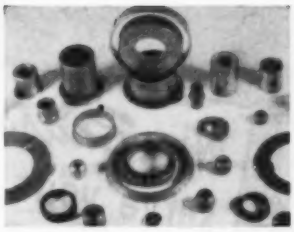

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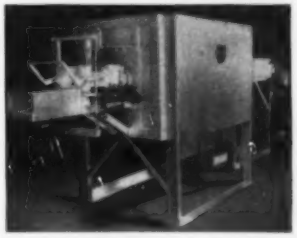

Model HOU-8436-MI-21 Harper Electric Furnace with cooling chamber for sintering, brazing, and annealing operations. Parts to be treated are charged and discharged manually in this alloy muffle furnace with water-cooled exit chamber. Simple sturdy construction of this unit, providing economy of atmosphere allows for maximum working at low investment cost.

Whether your heat treating requirements call for research or production units you will want to investigate the versatile features of Harper Electric furnaces for sintering metal powder products and other processes.

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★ Flexible design permits variation and duplication of heating cycles.

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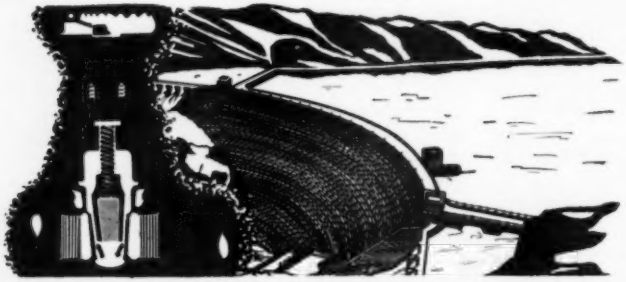

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441. Furnaces

40-page booklet, B-5459, "Harnessing Heat", describes twelve different types of gas and electric furnaces and their applications. Also, a section on the four basic types of protective atmospheres and a glossary of heat treating terms. *Westinghouse*

442. Furnaces

Complete catalog available describing high-speed gas furnaces designed primarily for heat treating high-carbon and alloy steels; also pot furnaces for salt, cyanide and lead hardening. *Charles A. Hones, Inc.*

443. Furnaces

Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000 °F. *Harper Electric Furnace*

444. Furnaces, Annealing

Folder of performance and cost data on radiant tube and roller hearth furnaces. *Gas Machinery Co.*

445. Galvanizing Furnace

4-page article describes installation of galvanizing furnace at Fairbanks-Morse. *Sunbeam Corp.*

446. Gas-Air Mixers

8-page bulletin 5-C gives engineering data on selecting and matching burners and mixers. Master table enables selection of mixer for any type of fuel gas. *Bryant Industrial Div.*

447. Gas Burner Nozzles

Catalog 804-C gives capacities and other data on 19 sizes of straight and elbow-type nozzles. Spark and gas pilot ignition also explained. *Hauck Mfg.*

448. Gas Carburizer

Bulletin 1212 illustrates and describes No. 4 rotary gas carburizer for use with small parts. *American Gas Furnace Co.*

449. Gas Cutting Machine

Catalog on Airco No. 50 Travograph gas cutting machine, with manual, magnetic, or automatic tracing device to cut intricate shapes. *Air Reduction*

450. Graphitic Tool Steels

48-page data booklet contains heat treating data, properties and 46 specific applications of four types of graphitic tool steel. *Timken*

451. Graphitization

12-page booklet gives 10-year research findings on graphitization in steel castings. *Edward Valves, Inc.*

452. Hardness Tester

4-page bulletin on Brinell hardness tester weighing 26 lbs. for portable and stationary use. *Andrew King*

453. Hardness Tester

Bulletin F-1689-1 on Impressor hardness tester for aluminum, copper, brass, bronze, plastics. *Barber-Colman*

454. Hardness Tester

Literature on Brinell testing machines. *Detroit Testing Machine Co.*

455. Hardness Tester

Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. *Wilson Mechanical Instrument Co.*

456. Heat-Resisting Paint

Bulletin 112351 describes metallic paint which withstands temperatures up to 1700° F. Data on composition, uses, method of application. *Speco, Inc.*

457. Heat Treating

Information on "Sure-Wear" process for heat treating high-speed cutting tools. *LR Heat Treating Co.*

458. Heat Treating

Bulletin 120 tells how heat exchangers provide heat control in quenching bath, thus protecting physical properties and saving on water and piping equipment. *Niagara Blower*

459. Heat Treating

Ipsenlab periodic sheets show case histories on bright hardening, annealing and carburizing. *Ipsen Industries*

460. Heat Treating

40-page booklet on facilities for heat treating. *Commercial Steel Treating*

461. Heat Treating Ammonia

Literature on standard anhydrous ammonia for heat treating. *Nitrogen Div., Allied Chemical & Dye Corp.*

462. Heat Treating Compounds

Technical data sheets describe Aeroheat 300 for tempering and drawing and Aeroheat 1200 for martempering, tempering & drawing. *American Cyanamid*

463. Heat Treating Fixtures

Catalog B-8 describes and shows 75 custom-built fabricated alloy heat treating accessories. *Rolock*

464. Heat Treating Fixtures

Information on standard carburizing carriers that will handle odd-shaped parts through carburizing and quenching to finishing. *Pressed Steel Co.*

465. Heating Elements

24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes available. *Globar Div., Carborundum Co.*

466. Heliarc Welding

Pocket-sized folder contains current ranges and sizes for electrodes with table on current and number of passes required to weld various metals. *Linde Air Products*

467. High-Temperature Alloys

"Thermalloy 30" gives property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

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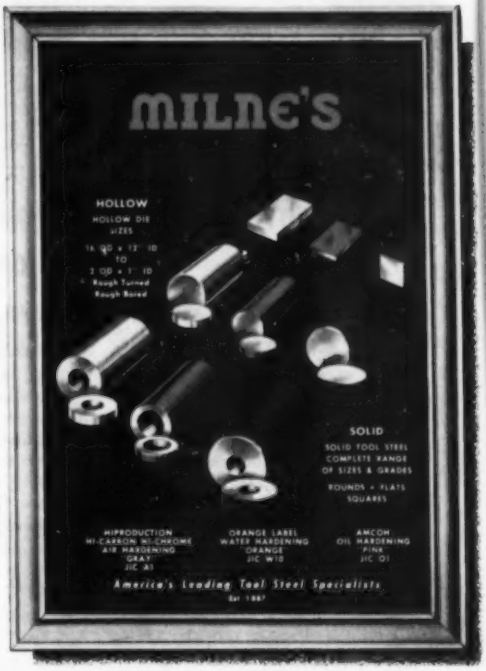

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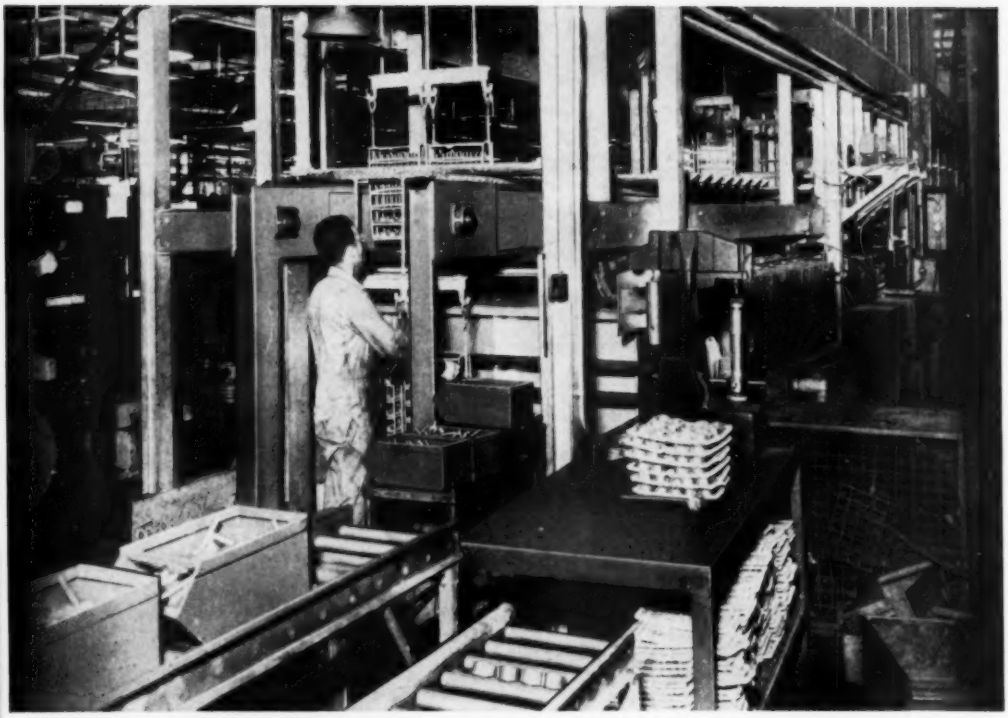

Conversion to liquid carburizing increases production ... saves on capital investment

COMPLETE REPLACEMENT of gas carburizing units by a fully mechanized liquid system has increased production from 3,000 to 10,000 units per day at a large manufacturing plant. And replacement expense was considerably lower than the cost of additional gas units necessary for comparable output! Compact in-line liquid equipment has put carburizing on an economical mass production basis —producing cases of exceptional uniformity at a fraction of former labor and operating costs.

Plants everywhere are finding that the advantages of liquid carburizing are not confined to savings and faster operation. For the buoyancy of the bath in this efficient process relieves parts of strain . . . reduces the danger of distortion. What's more, the fast, even heating properties of the carburizing bath assure cases of maximum uniformity—even when parts have extremely irregular sections.

Perhaps *your* plant can profit by converting to a molten salt bath process. Get in touch with your nearest Du Pont office today. Our technical representatives will be glad to help you on heat treating problems, selection of materials, and the planning of equipment. E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Dept., Wilmington 98, Delaware.

There's a Du Pont molten salt bath for every heat treating need. Sodium Cyanide, Accelerated Salt WS,* and Carburizing Salt—for shallow, medium and deep cases—are just three of the Du Pont heat treating materials that can mean top production and maximum economy for your plant.

*Water Soluble

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DU PONT CYANIDES and SALTS for STEEL TREATING

150th Anniversary

Better Things for Better Living . . . through Chemistry

ELECTROCHEMICALS DEPT. DISTRICT OFFICES: Boston, Charlotte, Chicago, Cincinnati, Cleveland, Detroit, El Monte (California), New York, Philadelphia

468. High-Temperature Alloys
High temperature work sheet provides valuable information and suggestions for solving high temperature problems in design and production. *International Nickel*

469. Impregnating Castings
Literature on new impregnating equipment for elimination of porosity in ferrous and nonferrous castings. *Metallizing Co. of America*

470. Impregnating Castings
Folder on 6-step impregnation process to eliminate porosity in castings. Includes data on impregnating material. *American Metaseal*

471. Impregnation of Castings
Bulletin on sealants, methods and service to correct microporosity in ferrous and nonferrous castings. *Polyplastex International*

472. Induction Heating
Catalog MP-8 describes portable high frequency induction heating unit for brazing, hardening, soldering, annealing and melting. *Lepel High Frequency*

473. Induction Heating
Bulletin 1440 furnishes full details on the "Checklite" system for safety control through the use of oversized components built into every unit for longer service life and uninterrupted production. *Lindberg Engineering*

474. Induction Heating
New 60-page catalog, "Tocco Induction Heating", tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

475. Induction Heating
"Induction Heating . . . the machine tool that makes tall stories come true" presents case histories of increased production, reduced space and lower costs. *Westinghouse*

476. Industrial Planning
Book 127 tells how you can share in a "round-table" discussion of planning expansion, remodeling or modernization of your plant. *Continental Industrial Engineers, Inc.*

477. Inert Gas Welding
Heliwelding, inert, gas-shielded arc-welding process for all-position welding of aluminum, magnesium, stainless steel, brass and copper, in ADC-709, Catalog 9. *Air Reduction Sales*

478. Inspection
20-page bulletin on high-speed automatic gaging and sorting; 43 applications are illustrated. *Federal Products*

479. Inspection Stamps
16-page catalog of letter, figure and inspection stamps, marking dies and numbering machines. *Dickey-Grabler*

480. Instruments
"Tomorrow Is Today" is a new brochure telling of the many contributions of instruments to industrial processing. *Minneapolis-Honeywell*

481. Iron-Nickel Alloys
32-page bulletin on austenitic iron-nickel alloys having special thermal expansion or thermoelastic characteristics. *International Nickel*

482. Iron, High Chromium
"Abrasion-Resistant High-Chromium Iron" furnishes a complete file of information on how to make and use abrasion-resistant iron castings most efficiently. *Electro Metallurgical Co.*

483. Iron Powder
Information on sponge iron powder. *Ekstrand & Tholand*

484. Laboratory Furnaces
Series of data sheets give full information on complete line of laboratory furnaces for numerous metallurgical operations. *Boder Scientific*

485. Laboratory Safety
40-page booklet includes recently developed data, techniques and equipment, and provides useful manual for setting up complete laboratory safety programs. *Fisher Scientific*

486. Leaded Steels
Folder on lead-bearing, cold finished bars which machine about 80% faster than B1113. *LaSalle Steel*

487. Liquid Carburizing
Data folder on Aerocarb A and B compounds for salt-bath carburizing. Case depth versus time, % C and % N penetration curves. *American Cyanamid*

488. Lockseam Tubing
Blueprint of available size ranges of round or oval lockseam tubing in a wide range of metals. *H & H Tube and Mfg.*

489. Lubricant
40-page booklet on Moly-sulfide lubricant records experience with 154 different uses. *Climax Molybdenum*

490. Lubricant, Metalworking
Uses of colloidal graphite for hot metal-working operations (deep piercing, forging, stretch-forming and wire drawing operations) explained in bulletin 426-10-H. *Acheson Colloids*

491. Machining Copper Alloys
32-page booklet gives cutting speeds, feeds, rakes, clearances for more than 40 copper alloys. *American Brass*

492. Machining Titanium
Article on recommended practices for machining titanium, from first issue of "Titanium Review". *Rem-Cru Titanium*

Bright-brazed and bright-hardened parts, courtesy Hamilton Standard Division, United Aircraft Corporation.

WITH A **SARGEANT & WILBUR**
CONVEYOR FURNACE

Now, parts made of stainless can be BRIGHT-ANNEALED, BRIGHT-HARDENED or BRIGHT-BRAZED without oxidation, on a continuous production basis. They come from the controlled-atmosphere conveyor furnace scale-free, bright and clean.
No pickling, sand blasting or tumbling required. These costly operations are eliminated, so your parts retain their sharp design and edges. A special Sargeant & Wilbur alloy for bright-brazing makes the joint practically invisible because it resists dulling and matches the metal color perfectly. Steel and non-ferrous metal parts are brazed in the same operation with excellent results.

Your samples processed FREE. To see your products bright-brazed, send samples and specifications.

SARGEANT & WILBUR INC. 186 Weeden Street PAWTUCKET, R. I.

Send for free illustrated booklet giving more information on the Sargeant & Wilbur Conveyor Furnace.

Name .....
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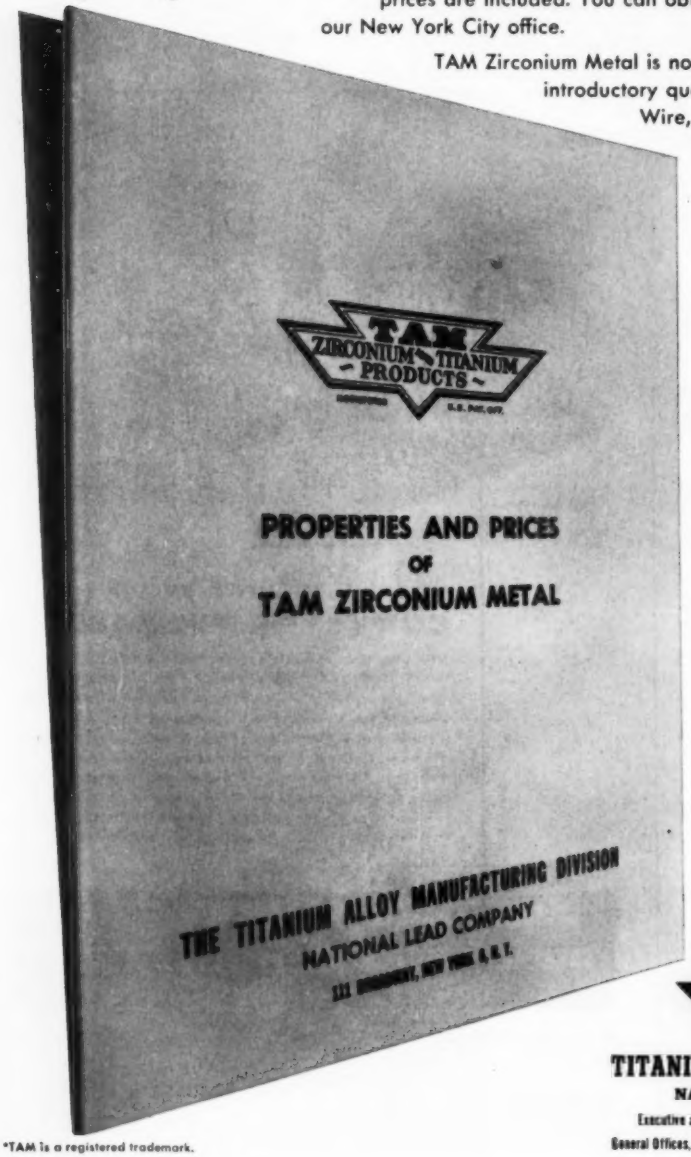
points up the advisability of a thorough investigation. And, this new booklet gives you many of the answers. Physical, mechanical and chemical properties are charted and detailed. Present and potential uses, supply and prices are included. You can obtain your copy by writing our New York City office.

TAM Zirconium Metal is now available, in limited introductory quantities of Bars, Rods, Sheets, Wire, Sponge and Briquettes.



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TITANIUM ALLOY MFG. DIVISION
NATIONAL LEAD COMPANY
Executive and Sales Offices: 111 BROADWAY, NEW YORK CITY
General Offices, Works and Research Laboratories: NIAGARA FALLS, N. Y.

*TAM is a registered trademark.

493. Magnesium
42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

494. Magnesium Melting
Bulletin describes use of fabricated Amera-Mag steel crucibles in melting magnesium. *American Tank & Fab.*

495. Manganese Bronze
Article discusses effects of lead and tin on mechanical properties of manganese bronze and effects of arsenic, antimony, phosphorus, lead and tin on dezincification. *R. Lavin & Sons*

496. Martempering of Gears
Article gives two case histories on martempering of aircraft gears. *Ajax Electric*

497. Mechanical Cleaning
76-page catalog 210 simplifies selection of power brushes; contains numerous illustrations of various types of brushes in operation. *Osborn Mfg.*

498. Melting Furnaces
8-page Bulletin 560 describes stationary and tilting types of two-chamber melting furnaces. Applications to sand, permanent mold, centrifugal and die casting. *Lindberg Engineering*

499. Melting Furnaces
24-page book on electric furnaces for steel mills and foundries. Many photographs of furnaces in action. Table of types, sizes, ratings. *American Bridge*

500. Melting Pots
Bulletin 201-B on alloy cast iron melting pots for use in aluminum foundries, die-casting plants and smelting works. *American Car and Foundry*

501. Metal Conveyor Belts
44-page illustrated catalog describes metal belts for quenching, tempering, annealing, hardening, brazing, carburizing, powder metallurgy and other applications. *Ashworth Bros., Inc.*

502. Metal Cutting
64-page catalog No. 28 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

503. Metallograph
Revision of catalog includes the new metallograph with polarizing and phase attachments. *American Optical*

504. Micrographic Equipment
6-page bulletin on a universal camera microscope giving plate magnifications from 4 to 3000 ×. Full details on optics and accessories included. *Opplem Co.*

505. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Kent Cliff Laboratories*

506. Nickel Alloys
Booklet, "Hastelloy Nickel-Base Alloys", gives full details of their use for fabricating corrosion-resistant screen, cloth and baskets and for metal spraying and hard facing. *Haynes Stellite Co.*

507. Nickel Plating
12-page reprint, "Mechanical Properties of Nickel Deposits", deals with effects of plating variables on properties. 13 charts, 3 tables, 40 micrographs. *International Nickel*

508. Nickel Steel
12-page reprint, "Properties of Low-Carbon 8½% Nickel Steel", on fabrication and low-temperature properties (at −320° F.) of this 0.06% carbon alloy steel. *International Nickel*

509. Nondestructive Testing
Data on electronic inspection equipment and comparators for sorting. *Magnetic Analysis*

510. Nondestructive Testing
Series of bulletins gives data on both ultrasonic and magnetic testing instruments. Illustrated. *J. W. Dice Co.*

511. Nonferrous Tubing
Folder on company's tubular products in copper, brass and aluminum, including special finned and corrugated tubing. *Fromson Orban Co.*

512. Nonferrous Tubing
Bulletin on seamless, brazed and lockseam tubing in brass and copper. *H & H Tube and Mfg.*

513. Oil Firing
Catalog 715 explains an easy means of standby oil firing for plants having seasonal shortages of natural gas. *Hauck Mfg.*

514. Oil Quenching
Catalog V-1146 on self-contained oil cooling equipment. Detailed solutions to typical problems. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett Co.*

515. Parts Dryer
Bulletin gives specifications and drawings of centrifugal dryer for small parts. *Nobles Engineering and Mfg.*

516. Pickling
Bulletin on heating and agitating pickling solutions. *Ozark-Maltoning*

517. Plating
Bulletin CR-110-5 describes equipment, bath, operating conditions and control of high-speed chromium plating process. *United Chromium*

518. Plating Control
Data on instruments for control of plating solutions and on other plating equipment. *Demott Industries*

519. Plating Rack Coating
Data sheet on coating 219X for protection and insulation of plating racks. *United Chromium*

*Why melt magnesium the *AMERA-MAG way?*

BECAUSE these facts prove why AMERA-MAG Steel Melting Crucibles outperform them all for quality, life, safety, and economy:

- *Made of* AMERA-MAG *Steel—no copper, nickel contamination.*
- *500,000 in use—no failures.*
- *Last up to 3 times longer—at no extra cost.*
- *A.S.M.E. welded—safer, no cracks or leaks.*
- *Resists high heat and distortion—better heat transfer.*
- AMERA-MAG *is certified.*

Learn how AMERA-MAG Steel Crucibles together with AT&FCO's practical engineering can help you eliminate your magnesium melting and casting problems.
Write or call for further information.

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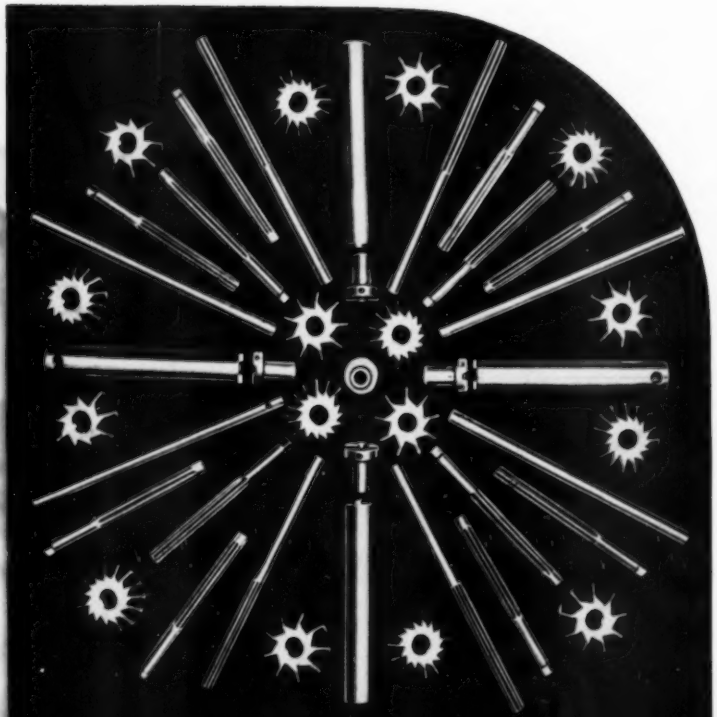
American

TANK & FABRICATING CO.
2284 Scranton Road, Cleveland 13, Ohio
Telephone MA 1-6296

Another **FIRST** *for Super Scottsonizing!*



CUTTERS and REAMERS of
18-8 STAINLESS STEEL

The amazing hardening qualities produced by the Super Scottsonizing Process now make possible, for probably the first time, the use of 18-8 Stainless Steels for Milling Cutters and Reamers.

The cutters and reamers are completely finished to size before Super Scottsonizing. Without lapping the hole or grinding the face of the cutter, they are then used for cutting steel and cast iron.

Not only cutters and reamers of 18-8 benefit from this extraordinary treatment, parts weighing up to 500 and 600 pounds, 6" and 8" in diameter, have been successfully Super Scottsonized and held to size within $\frac{1}{4}$ of $\frac{1}{10,000}$.

Investigate the possibilities of Super Scottsonizing of stainless steel precision parts wherein a tolerance of $\frac{1}{4}$ of $\frac{1}{10,000}$ is mandatory. The real merits of our product can best be appreciated through actual test.

Remember — good heat treating makes a good product — BETTER!

ESTABLISHED 1906

C. U. SCOTT & SON, Inc.

STEEL TREATING - TOOL HARDENING
SCOTTSONIZING

ROCK ISLAND, ILL. **Telephone: RI 8-3443**

First Custom Heat Treating Plant Established in United States

1510 First Avenue

520. Plating Racks

8-page booklet offers data on a plating rack designed to make the spline section or body of the plating rack a permanent tool. *National Rack*

521. Plating Rectifiers

Bulletin on selenium rectifiers for electroplating and anodizing. *Wesley Block & Co.*

522. Polishing and Buffing

6-page bulletin on application of single-spindle machine in polishing formed parts having either plane or curved surfaces. *Vanott Machine Corp.*

523. Portable Potentiometer

Bulletin A502 discusses lightweight portable potentiometer accurate to 0.025 mv. *Wheelco*

524. Portable Potentiometer

Bulletins 270 and 270-A describe portable potentiometers in a selection of ranges up to 1.6 volts. *Rubicon*

525. Powder Metallurgy

Data sheet on zinc stearate as a lubricant in powder metallurgy. *American Cyanamid*

526. Precision Casting

12-page illustrated booklet on precision casting with emphasis on the most widely used equipment and supplies. Check list of applications in various fields. *Alexander Saunders & Co.*

527. Precision Castings

12-page booklet, "Pour Yourself an Assembly", describes wide range of applications and alloys for precision casting. *Precision Metalsmiths*

528. Press Forging

Bulletin on advantages of press forging for many types of parts. *Ajax Mfg.*

529. Presses, Bending

Presses for bending, forming, blanking, drawing and multipunching are described in catalog 2010. *Cleveland Crane & Engineering*

530. Proportioning Controller

Bulletin 1052 describes indicating millivoltmeter controller with time-proportioning action. *Minneapolis-Honeywell*

531. Protective Chemicals

Quick reference list of rust proofing, paint-bonding and metal protective chemicals is intended for all fabricators of steel, zinc and aluminum products. *American Chemical Paint*

532. Pump for Liquid Metal

Bulletin 876 on electromagnetic pump for pumping liquid metal having electrical resistance equal to or less than stainless steel. *General Electric*

533. Pyrometer Equipment

A new Buyers' Guide for pyrometer supplies, No. 100-4, is ready for distribution. *Minneapolis-Honeywell*

534. Pyrometers

Catalog No. 165 describes improved Pyro surface pyrometer. Eight instruments in one, it handles surface and subsurface temperature measurement. *Pyrometer Instrument Co.*

535. Pyrometers

Complete information on Xactemp pyrometers: Type LT-840 and all accessories are illustrated and described; also Xactline straight-line temperature control for use with any standard pyrometer controller. *Claud S. Gordon Co.*

536. Quench Conveyor

8-page bulletin on continuous quench tank conveyor and other production equipment. *The Klaas Machine & Mfg.*

537. Quenching Additive

8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

538. Recorder Controllers

48-page catalog ND 46(1) gives specifications, numerous installation pictures of recorders and controllers for temperature, stress, strain and other variables. *Leeds & Northrup*

539. Recording Potentiometer

Folder on new, simplified single-point recorder of the potentiometer type, for many uses. *Weston Electrical Instrument*

540. Refractories

20-page booklet gives technical information of a basic nature on super refractories. Contains text, charts, tables, illustrations and application data. *Refractories Div., Carborundum Co.*

541. Refractories

New 12-page brochure presents products for casting special refractory shapes and for gunning and slap troweling applications, for services through 3000° F. *Johns-Manville*

542. Refractories

Form 1409 describes fused stabilized zirconia for furnace linings, metal melting, and other uses. *Norton Co.*

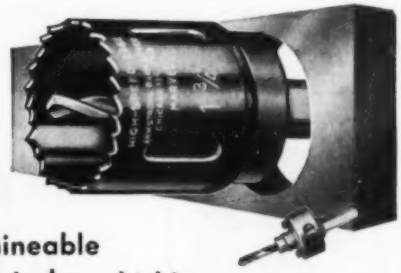
543. Refractories

Revised bulletin entitled "Lumnite Refractory Concrete" discusses latest available data on refractories and heat-resistant concrete. *Lumnite Div.*

544. Refractory Mixes

Well-illustrated 16-page bulletin No. 315 provides important data on properties and applications of Sillimanite super-refractory ramming mixes and patches. *Chas. Taylor Sons Co.*

Cut...



LARGE HOLES

... thru any machineable material up to 1⅛ inches thick!

Here is a premium tool which makes it possible to saw holes in one short operation ... large holes which heretofore had to be laboriously machined "a-chip-at-a-time."

MARVEL High-Speed-Edge Hole Saws have strength to withstand the terrific peripheral strains of heavy duty operation in lathes, drill presses or portable power tools. They have a high speed steel cutting edge which is electrically welded to a tough, alloy steel body, high speed steel pilot drills, heavy hexagonal shanked arbors and sufficient set for deep drilling. They are self-aligning, as the larger diameter saws float on their arbors and are driven by double drive pins. They will saw round holes accurately in any machineable material.

MARVEL High Speed-Edge Hole Saws come in 35 sizes, from ⅜" to 4½". They are carried in stock by leading industrial distributors.

WRITE FOR BULLETIN ST-49

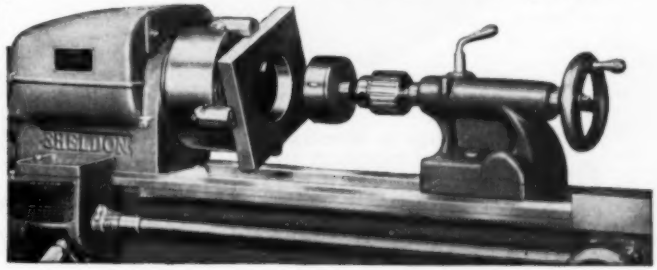
"MARVEL" has Always had the edge!

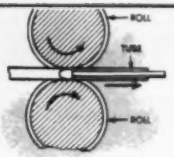
MARVEL SAWS

ARMSTRONG-BLUM MFG. CO.

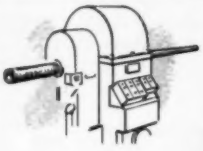
"The Hack Saw People"

5700 Bloomingdale Avenue — Chicago 39, U. S. A.



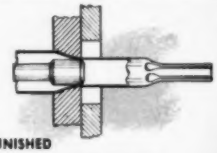


HOT-FINISHED
bears the scale formed during hot fabrication or heat treatment.



TURNED
machined, uniform O.D.

take
a closer look at
YOUR
Finishing Time

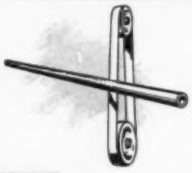


COLD FINISHED

ROTO-ROCKED
Smooth surfaces, obtained by special sizing and finishing processes.

COLD DRAWN
Smooth, scale-free surface.

PICKLED
de-scaled by one of several solutions.



POLISHED
O.D. and/or I.D. polished to one of several specified degrees of smoothness.

FLASH-IN
ERW tubing which retains the bead formed by welding.

FLASH REMOVED
ERW tubing, bead-free.
Both available either as welded or normalized.

You aren't taking full advantage of the time savings and cost economies in the machining and fabrication of hollow parts from tubing *unless you start with tubing having the* ***PROPER SURFACE FINISH.***

By specifying tubing having a surface finish keyed to your production methods, you take an important step toward reducing the time it takes you to make your finishing operations.

As a specialty tube mill, B&W supplies mechanical tubing in the variety of surface finishes illustrated.

Your choice should be influenced by your production facilities and consideration of the cost differentials among the several finishes.

In any case, remember that the tubing *you* can use is more than merely bar stock with a hole in it.

It can be delivered to you as a product ready for you to convert—in the shortest possible time and with least cost—into your finished product. Mr. Tubes—your B&W Tube Representative can help you select the tubing and finish most suitable for your specific end uses.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
General Offices & Plants
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

Sales Offices: Beaver Falls, Pa. • Boston 16, Mass. • Chicago 3, Ill. • Cleveland 14, Ohio • Denver 1, Colo. • Detroit 26, Mich. • Houston 19, Texas • Los Angeles 17, Cal. • New York 16, N. Y. • Philadelphia 2, Pa. • St. Louis 1, Mo. • San Francisco 3, Cal. • Syracuse 2, N. Y. • Toronto, Ontario • Tulsa 3, Okla.

B&W SEAMLESS and WELDED TUBES

TA-1690M

COMPACT

ACCURATE

LIGHT WEIGHT

DEPENDABLE

SERIES 300

wheelco

PORTABLE POTENTIOMETER

Designed for precise checking and calibrating of temperature measurement and control instruments, the Wheelco Portable Potentiometer is a versatile instrument.

• Entirely self-contained, it requires no external accessories. A special compartment accommodates dry cells for supplying current to the potentiometric circuit.

• Accurate to .025 millivolts, sturdily constructed for long laboratory or field service, convenient in size, weight and portability — the Wheelco Potentiometer is RIGHT for your requirements.

FOR A COMPLETE DISCUSSION OF FEATURES AND SPECIFICATIONS SEND FOR BULLETIN A502

FOR LABORATORY, PLANT AND FIELD SERVICE WORK

- ACURATE TO .025 MILLIVOLTS
- COMPLETELY SELF-CONTAINED
- STURDY ALUMINUM FRAME

BARBER COLMAN

instrumentality

wheelco instruments division

BARBER-COLMAN COMPANY

1225 ROCK STREET • ROCKFORD, ILLINOIS

545. Resistance Welding
12-page bulletin SP351 on nine basic types of resistance welders. *Federal Machine and Welder*

546. Rhodium Plating
Directions for rhodium plating, with reference to use as replacement for usual plating metals. *Baker & Co.*

547. Rotary Straightener
Catalog describes two-roll rotary straightener for round tubes and bars $\frac{1}{16}$ to $\frac{3}{16}$ in. O.D. *Medart Co.*

548. Safety Valves
Bulletin 400 describes safety valves for instantaneously shutting off fuel in case of power failure to some essential unit. *Western Products*

549. Salt Bath Descaling
12-page bulletin B-40 describes continuous and batch descaling lines for removing oxide from steel, bronze, copper, stainless and titanium. *Drever Co.*

550. Saw Blades
Bulletin on power hacksaw blades of M-2 type high speed steel. *Henry G. Thompson & Son*

551. Saws
Catalog 40 describes 35 models of metalcutting saws, including fast, automatic production saw, hydraulic hacksaws and widely used small shop saws. *Armstrong-Blum Mfg.*

552. Scale Removal
Article on continuous hydride descaling at plant of Sharon Steel Corp., from "Modern Metal Finishing". *Du Pont*

553. Screw Machine Steels
Comparison of the four classes of screw machine steels, in regard to machining, forming, carburizing and other characteristics. *LaSalle Steel*

554. Selective Carburizer
Bulletin on "No-Carb" for selective carburizing and prevention of decarburizing on high alloy steels during heating for hardening. *Park Chemical*

555. Shell Molding
See review on p. 17.

556. Silicone-Base Finish
New brochure on silicone-base heat-resistant finish. *Midland Ind. Finishes*

557. Silver Brazing
48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

558. Soaking Pit
Technical bulletin with details on construction and performance of new soaking pit which will reduce fuel used by 40% while almost doubling amount of steel heated. *Loftus Eng'g.*

559. Solder Stripper
Data sheet on alkaline material for stripping tin, lead and lead-tin without attaching base metal. *Enthone*

560. Soldering Equipment
8-page brochure on soldering and brazing equipment describes new Mogul soldering gun and shows its applications to production-line soldering and brazing. *Metallizing Co. of America*

561. Solvent Cleaning
24-page brochure describes medium-pH cleaner for use following solvent degreasing or other precleaner. Other products included in brochure also. *Northwest Chemical*

562. Specimen Grinders
6-page booklet describes belt and wheel-type grinders and surfacers designed for wet or dry grinding of metallurgical samples. *Buehler, Ltd.*

563. Specimen Mount Press
New bulletin describes AB speed press, available in three sizes. Special features are emphasized. *Buehler, Ltd.*

564. Spectrophotometer
Bulletin B-211 illustrates junior-size spectrophotometer for identifying and measuring solution constituents in analytical or production laboratories. *Harshaw Scientific Div.*

565. Springs
Information on compression, torsion, flat, extension and special springs. *John Evans Sons, Inc.*

566. Spring Steel
Handbook describes various spring steels and gives tolerance tables, heat treatment and physical property tables and fabrication data. *A. R. Purdy Co.*

567. Springs Tester
Bulletin on precision tester and its use in statistical quality control of springs. *Torrington Mfg.*

568. Stainless Castings
Reference charts give specification designations, analyses, properties and heat treatments for 17 standard corrosion and heat resistant alloy castings. *Lebanon Steel Foundry*

569. Stainless Fabrication
133-page book, "Fabrication of Stainless and Heat Resisting Steels", covers welding, riveting, soldering, joint design, machining, cutting, forming, annealing, pickling, surface finishing and protection of stainless steels. *U. S. Steel*

570. Stainless Fasteners
20-page catalog provides detailed product specifications to aid in selecting and ordering stainless steel fastenings. *Star Stainless Screw*

571. Stainless Fitting
Bulletin on new stainless steel f
for joining pipe or tube without th
ing or welding. *Cooper Alloy Fo*

572. Stainless Steel
8-page guide to Enduro stainless
composition, physical, electrical
mechanical properties of 300 an
series. Corrosion data for 600 mec
Republic Steel

573. Stainless Steel
Weekly lists with analyses o
plates in stock. *G. O. Carlson, In*

574. Stainless Steel
Slide chart. Set top at a c
fabricating operation, bottom
rating of each standard grade. C
verse side, heat treating and cor
data are given. *Carpenter Steel*

575. Stainless Steel Powde
Bulletin 2 gives tensile, hardnes
density properties for a new 18-8
less powder as function of mesh
sintering temperature and compa
pressure. *Vanadium-Alloys Steel*

576. Steel, Aircraft
62-page "Aircraft Steels" bookl
cludes revised military specifica
Also sizes and analyses of aircraft
in stock. *Joseph T. Ryerson &*

577. Steel, Low-Alloy
Booklet on Hi-Steel, with nearly
the working strength of ordinary
plus impact resistance. *Inland St*

578. Steel, Low-Alloy
8-page folder on N-A-X low
high-strength steels lists properti
test specifications. *Great Lakes*

579. Steel Tubing
24-page bulletin 17 on mech
applications of steel tubing. Man
illustrated. *National Tube Div.*

580. Stereomicroscopes
20-page brochure on microscop
three-dimensional magnification
45 diameters. *Bausch & Lomb O*

581. Straightening Coil St
Equipment described for feedin
straightening coil stock for star
blanking or shearing. *F. J. Lit*

582. Straightening Wire
Bulletin 52-AA describes straig
ing machine for wire in size range
$\frac{1}{8}$ to 1 in. diameter, at speeds
200 ft. per min. *Medart Co.*

583. Stress Analysis
Revised edition of "Photoelastic
Analysis" shows the engineer wh
method is effective for solving pr
of stress distribution. *Eastman*

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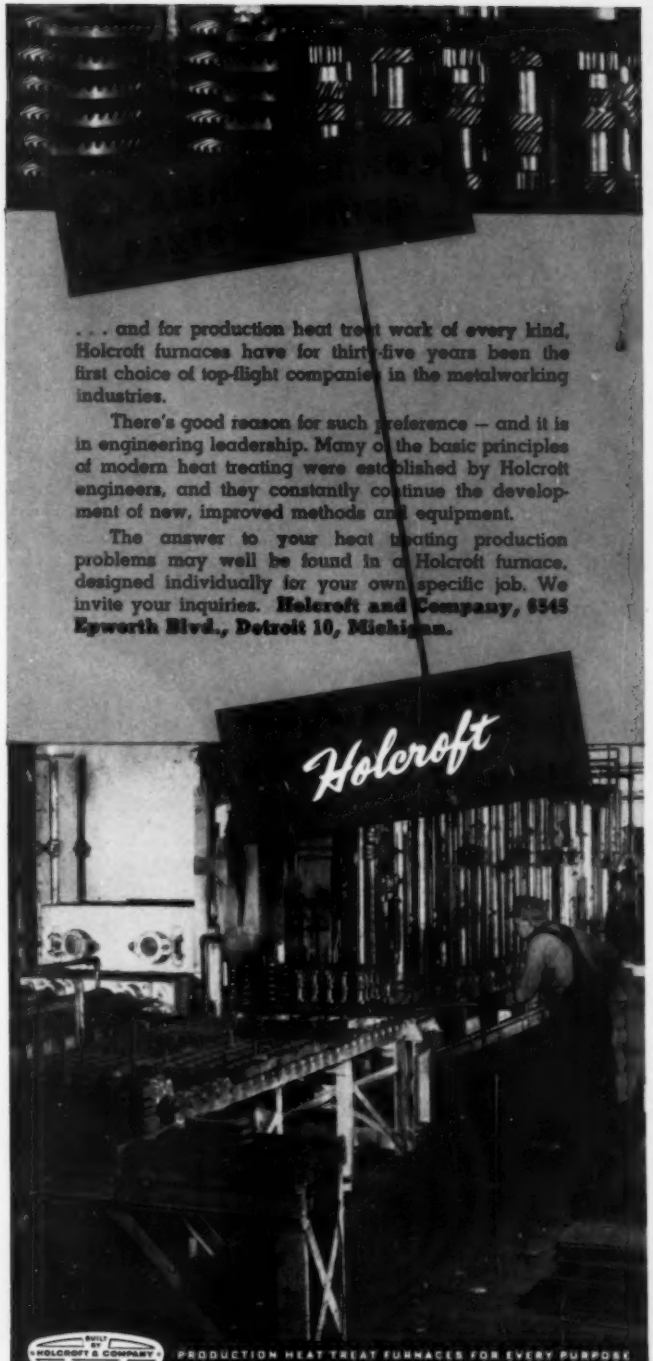

. . . and for production heat treat work of every kind, Holcroft furnaces have for thirty-five years been the first choice of top-flight companies in the metalworking industries.

There's good reason for such preference -- and it is in engineering leadership. Many of the basic principles of modern heat treating were established by Holcroft engineers, and they constantly continue the development of new, improved methods and equipment.

The answer to your heat treating production problems may well be found in a Holcroft furnace, designed individually for your own specific job. We invite your inquiries. **Holcroft and Company, 6545 Epworth Blvd., Detroit 10, Michigan.**

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HOUSTON 1 — R. E. McArdle, 5730 Navigation Blvd.
CANADA — Walker Metal Products, Ltd., Windsor, Ontario
EUROPE — S. O. F. I. M., Paris, France

584. Subzero Freezer

4-page folder on portable freezer, 110-volt a.c., operating to −180° F., for shrink fitting, hardening, stabilizing and testing. *Webber Appliance*

585. Surface Cleanliness

Bulletin 40 describes device to measure surface electrical resistance as criterion for effectiveness of a cleaning process. *Weltronic*

586. Temperature Control

36-page bulletin P 1245 on new electronic instruments for recording and indicating a wide variety of variables. Includes charts, wiring diagrams, many photographs. *Bristol Co.*

587. Temperature Control

Article describes control installation for gas-fired annealing furnace at Falk Corp. *Wheelco*

588. Temperature Control

Catalog of pyrometer supplies gives data on thermocouples, protection tubes, other accessories. *Arklay S. Richards*

589. Testing

Bulletin on mechanical and nondestructive testing and on certification in accordance with procedure set up by the American Standards Association. *American Standards Testing Bureau*

590. Testing Laboratories

72-page directory of independent research and inspection laboratories. *American Council of Commercial Labs.*

591. Testing Machine

New universal testing machine of 12,000-lb. capacity is presented in Bulletin 336. *Baldwin-Lima-Hamilton*

592. Testing Machines

Bulletin 44 describes hydraulic universal testing machines in capacities from 60,000 to 400,000 lb. *Tinius Olsen*

593. Testing Machines

30-page catalog on screw power universal testing machines and accessories includes illustrations and details of construction and specifications. *American Machine & Metals*

594. Thermocouple Data

42-page Bulletin TC-9 gives data and charts on thermocouples, radiation detectors, resistance bulbs and other instrument accessories. *Wheelco*

595. Thermocouples

44-page catalog EN-S2 describes couples and assemblies for general application and for special plant and laboratory uses. Tabular data on accuracy and limits of couples. *Leeds & Northrup*

596. Thermocouples

Catalog 30 H gives complete description of thermocouples, quick coupling connectors, panels, pyrometers, extension wires and accessories. *Thermo Electric Co.*

597. Thickness Tester

Bulletin on measurement of wall thickness from one side by sonic method. *Branson Instruments*

598. Titanium and Zirconium

16-page bulletin, "The Hydrimet Process", describes titanium and zirconium metal and hydride, and other metallurgical hydrides. *Metal Hydrides*

599. Tool Steel Color Guide

Color guide to estimate the temperatures of heated steels has heat colors on one side and temper colors on the other side. *Bethlehem Steel*

600. Tool Steel Selector

Twist the dial of the 9-in. circular selector and you can read off the tool-steel for your application. *Crucible Steel*

601. Tool Steel Selector

Selector is handy chart featuring general and heat treating data on nondeforming, water hardening, shock-resistant, hot work, high speed tool and hollow die steels. *A. Milne & Co.*

602. Tool Steels

Stock list of available tool and die steels. *Reliable Steel*

603. Tubing

10-page stock list of alloy and stainless steel tubing. *Babcock & Wilcox*

604. Tubing Chart

A chart covering the range of sizes of electric resistance welded tubing produced by company. *Babcock & Wilcox*

605. Tubing Failures

Factors affecting tube life in high-pressure, high-temperature applications are presented in 40-page booklet, the result of a great number of investigations of failures. *Babcock & Wilcox*

606. Turbo Compressors

New 12-page bulletin 126-A provides detailed information on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling and drying. Performance curves and tables of capacities for both vacuum and pressure applications are included. *Spencer Turbine*

607. Vacuum Metallurgy

Bulletin gives résumé of vacuum metallurgical operations and research and development facilities and services available to the metallurgist. *National Research Corp.*

608. Vanadium Recovery

6-page article, "Recovery of Vanadium and Other Alloys in the Acid Electric Furnace", from Vancoram Review. *Vanadium Corp.*

609. Vapor Degreaser

Vapor degreaser described and diagrammed in folder. Data on different models. *Topper Equipment*

610. Weld-Spatter Compounds

Data sheet GEC-866 on coatings that prevent adhesion of weld spatter. Fillet-weld gage and other accessories also described. *General Electric*

611. Welded Steel Pipe

36-page brochure, "Continuous-Weld Pipe", describes manufacture and gives tabular data on various types of the product. *Wheeling Steel*

612. Welding and Cutting

64-page catalog of welding and cutting equipment, supplies, and accessories. *Southern Oxygen Co.*

613. Welding Magnesium

Article on inert-gas-shielded metal-arc welding of magnesium includes numerous illustrations and tables of data. *Dow Chemical*

614. Welding Nickel

New 44-page book on fusion welding of nickel and high-nickel alloys. Illustrated and containing more than 30 tables. Both electric arc welding and gas welding. *International Nickel*

615. Weldments and Castings

24-page book, "Facts About Weldments and Castings", gives basic engineering facts about steel plate fabrication as compared with castings. *Acme Tank & Welding*

616. Wire Straightening

Bulletin 52-C describes precision machine for straightening small wire with extreme accuracy. Applies to round wire 0.007 to 0.125 in. diameter of ferrous or nonferrous metal. *Medart Co.*

617. X-Ray Inspection

Bulletin 400-520 on jib-crane unit for applications where horizontal and vertical travels of standard tubestand are inadequate. *Westinghouse*

618. Zirconium

New price schedule and data on pure ductile zirconium. *Foote Mineral Co.*

619. Zirconium Metal

New booklet gives physical, mechanical and chemical properties, present and potential uses, supply and prices. *Titanium Alloy Mfg.*

August, 1952

301	326	351	376	401	426	451	476	501	526	551	576	601
302	327	352	377	402	427	452	477	502	527	552	577	602
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325	350	375	400	425	450	475	500	525	550	575	600	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

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Postcard must be mailed prior to Nov. 1, 1952.
Students should write direct to manufacturers.

Use WELDED STEEL for Greater Strength with Less Weight!

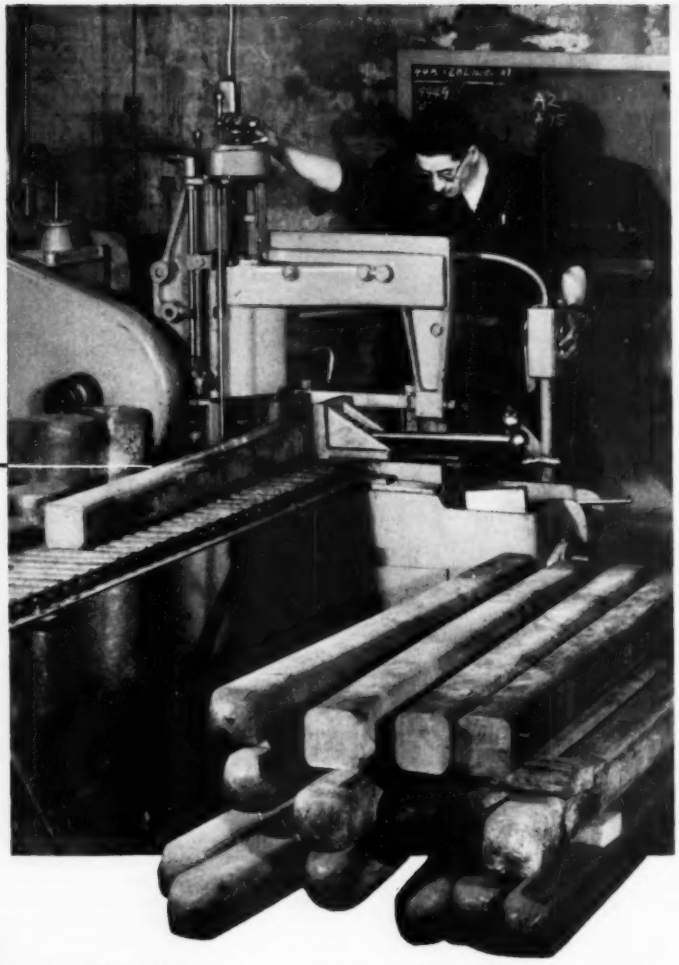
The twenty-ton weldment above is one of many heavy fixture parts produced by Mahon for the defense production program. It, and the Steel-Weld Fabricated parts and assemblies illustrated at the left, are typical of thousands of units Steel-Weld fabricated and machined by the Mahon Company for manufacturers throughout the country. Do you have parts or assemblies in your product that could be redesigned for more economical production in welded steel? . . . do you have products in the development stage in which Steel-Weld fabricated parts could reduce weight without sacrificing strength? . . . are you faced with limited production on an item involving heavy pieces in which pattern costs are a consideration? If so, it will pay you to familiarize yourself with Mahon facilities and technical services . . . you will find in the Mahon organization a unique source with complete, modern fabricating, machining and handling equipment to cope with any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures you a smoother, finer appearing job, embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

Serving up TONS of Vacuum Melted Metals



Preparing samples of vacuum melted metals for analysis.

PRODUCTION on vacuum melted metals that was formerly measured in pounds can now be measured in tons. Vacuum Metals' new expanded facilities are capable of producing 5 tons per day of Gas Free High Purity metals and alloys.

Vacuum melting techniques provide metals of higher purity . . . and alloys held to closer composition tolerances than ever before achieved commercially.

The unusual physical, chemical and electrical properties of these metals have proved of particular value for applications such as electronic and electrical parts, magnetic materials, bearing materials, diaphragms, instrument components, and Atomic Energy projects.

Metals now being vacuum melted include copper, nickel, iron, and molybdenum. Further information will be furnished gladly on request.

HIGH PURITY METALS
HIGH VACUUM CASTING
SPECIAL ALLOYS
GF (Gas Free) METALS

VACUUM METALS CORPORATION
Subsidiary of National Research Corporation
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Customer Reports:

23% Production Cost Saving with Asarco Continuous-Cast Bronzes!

Shorter machining time, longer tool life and less chip handling add up to a production cost saving of more than 23% since the MUELLER BRASS COMPANY, Port Huron, Michigan, large manufacturer of brass products, started using ASARCO Continuous-Cast Bronze for its "Streamline" plumbing fittings.

ASARCO Continuous-Cast Bronzes come in precise lengths to meet individual requirements, thus ending unnecessary scrap loss. Stock dimensions are held to close tolerances, providing a virtually finished product which saves machining time. For example, tube concentricities are within 1.5% of wall thickness, and tolerances are +.004" to −.006" on O.D. Absence of porosity, hard and soft spots, sand, dirt, dross or other foreign matter in stock permits high cutting speeds, lengthens tool life and improves products.

Alloy constituents are uniformly dispersed throughout Continuous-Cast Bronze. Fatigue characteristics are 33% to 100% better than those of the same alloys produced by other casting methods . . . impact strengths 15% to 100% higher . . . tensile strengths, yield strengths and hardnesses appreciably better.

ASARCO Continuous-Cast Bronzes are made to order in a wide range of alloy tubes, rods and shapes in any lengths up to 20'. SAE 660 (83% Cu, 7% Sn, 7% Pb, 3% Zn) is carried in stock.

ASARCO CONTINUOUS-CAST RODS · TUBES · SHAPES ®

West Coast Sales Agent:
KINGWELL BROS. LTD., 444 Natoma Street, San Francisco, Calif.

American Smelting and Refining Company
OFFICES: Perth Amboy Plant, Barber, New Jersey
Whiting, Indiana

Mail the coupon for a catalog containing full information on ASARCO Continuous-Cast Bronzes. It has tables, charts, photomicrographs and diagrams.

American Smelting and Refining Company
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Please send me a free copy of the 12-page catalog "Asarco Continuous-Cast Bronze."

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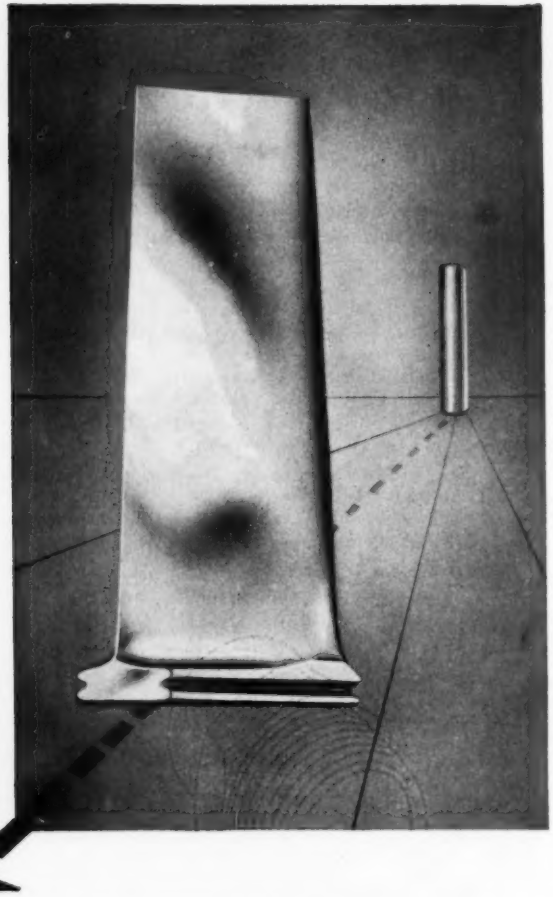


UTICA HELPS

BY SPEEDING STEPS BETWEEN BAR STOCK AND BLADE

Every military supplier has a *special* war to win. He must win his own race against his enemy counterpart.

As primary suppliers of forged turbine and compressor blades to the aircraft industry, UTICA is going at top speed. But that *alone* is not good enough — not for *this* race.

So we at UTICA examine our methods, study them, modify them, improve them. We seek always to speed, shorten and eliminate steps between bar stock and blade.

The job must be done today, for today is soon tomorrow. Tomorrow's method will not wait until the day after — not at UTICA.

UTICA DROP FORGE & TOOL CORPORATION, Utica 4, New York

MAKERS OF THE FAMOUS UTICA LINE OF DROP FORGED PLIERS AND ADJUSTABLE WRENCHES

SALT BATH BRAZING

...the fastest, cheapest production method!

✔ ***Work immersed in batches*** ... 5, 20 or 100 assemblies in each batch.

✔ ***All joints brazed simultaneously*** ... in seconds rather than in minutes.

✔ ***Decarburization of steel assemblies avoided***...no reheating needed. Clean surfaces assured for subsequent processing.

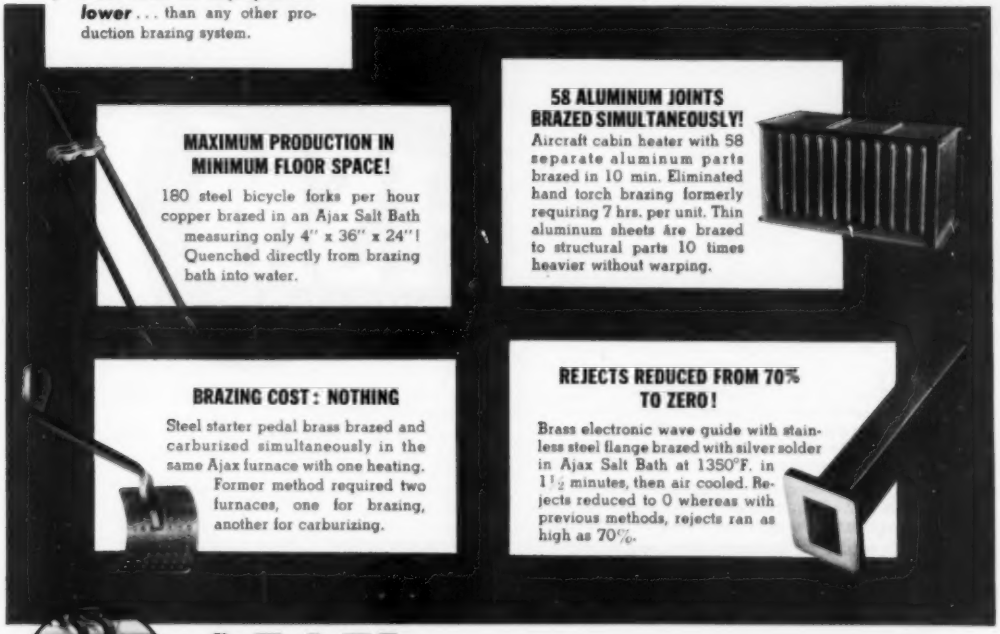
✔ ***No cooling chamber required*** ... no hydrogen atmosphere. 75% less floor space!

✔ ***First cost of equipment lower*** ... than any other production brazing system.

Ajax pioneered the salt bath brazing technique and proved that most ferrous or non-ferrous assemblies in production quantities can be brazed far faster and more economically by this method than by any other. Today this method is widely used by leading fabricators on a wide variety of work for brazing steel, cast iron, copper or aluminum assemblies.

In cases where a brazed assembly must also be hardened or carburized, the salt bath offers special economies because the brazing and hardening can be done simultaneously in a single heating operation.

Let us braze a job batch of your parts in our Metallurgical Service Laboratory. See how much faster your work can be handled, how much your product can be improved. Write for details.



MAXIMUM PRODUCTION IN MINIMUM FLOOR SPACE!

180 steel bicycle forks per hour copper brazed in an Ajax Salt Bath measuring only 4" x 36" x 24"! Quenched directly from brazing bath into water.

58 ALUMINUM JOINTS BRAZED SIMULTANEOUSLY!

Aircraft cabin heater with 58 separate aluminum parts brazed in 10 min. Eliminated hand torch brazing formerly requiring 7 hrs. per unit. Thin aluminum sheets are brazed to structural parts 10 times heavier without warping.

BRAZING COST: NOTHING

Steel starter pedal brass brazed and carburized simultaneously in the same Ajax furnace with one heating. Former method required two furnaces, one for brazing, another for carburizing.

REJECTS REDUCED FROM 70% TO ZERO!

Brass electronic wave guide with stainless steel flange brazed with silver solder in Ajax Salt Bath at 1350°F. in 1½ minutes, then air cooled. Rejects reduced to 0 whereas with previous methods, rejects ran as high as 70%.

SELF-HEATING • SELF-CIRCULATING

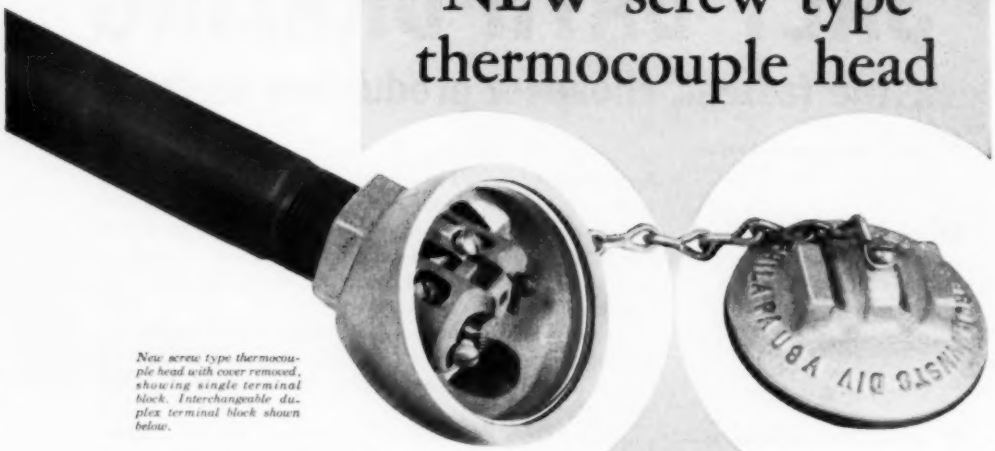
AJAX ELECTRIC SALT BATH FURNACES

AJAX ELECTRIC COMPANY, Inc. 910 Frankford Avenue, Philadelphia 23, Pa.

THE WORLD'S LARGEST MANUFACTURER OF ELECTRIC HEAT TREATING FURNACES EXCLUSIVELY

Associate Companies: **Ajax Electric Furnace Corp. • Ajax Electrothermic Corp. • Ajax Engineering Corp.**

NEW screw type thermocouple head



New screw type thermocouple head with cover removed, showing single terminal block. Interchangeable duplex terminal block shown below.

. . . now available through your

HSM

HONEYWELL SUPPLIES MAN

Here's a new Brown Screw Type Thermocouple Head that *cannot rust or freeze* . . . another plus value in the HSM Plan for convenient and economical purchasing of pyrometer supplies.

This unit effectively safeguards terminal connections from corrosive effects of high temperatures and extreme weather conditions.

Versatile: it accommodates single and duplex thermocouple, and resistance thermometer, terminal blocks . . . is interchangeable with other heads . . . and permits installation of twin thermocouples with a single head.

Thus, your inventory of thermocouple heads is materially reduced.

Threads on the inside of the head . . . plus plating and enameling *after* machining . . . prevent freezing and rusting.

Call your local Honeywell Supplies Man for prices and delivery information, and for details on the HSM Plan for all your pyrometer supplies purchases . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

● *Important Reference Data*

Write for a copy of New Pyrometer Supplies Buyers' Guide, No. 100-4

Full X-Ray Flexibility

assured for all-purpose inspection

Westinghouse 250 KV
JIB CRANE
X-RAY UNIT

Curtiss-Wright uses Westinghouse X-ray equipment for non-destructive testing of the important parts of their outstanding aircraft engines. The application pictured here shows the 250 KV X-ray tubehead, mounted on the jib crane tubestand, being positioned for the examination of the critical welds on gas turbine booster rotors.

The keynote for the selection of this equipment was *flexibility*—since *flexibility* results in more radiographs per shift.

1 Since the kilovoltage can be varied from 30-250 KV with greater X-ray output per KV resulting from the constant potential high voltage supply, the unit can be used to inspect materials from under ⅛" aluminum to 4" of steel.

2 The jib crane tubestand carries the tubehead from less than 3' up to 9' above the floor and from 50" to 14½' from the center of the vertical column which, in turn, can be rotated 135° in each direction. The tubehead mounting permits rotation of 180°, in either direction, around a vertical axis, and 140° around the long axis of the tubehead. The X-ray tube can be positioned easily and quickly to radiograph parts ranging in size from very small to very large.

Call your Westinghouse representative, or write to Westinghouse Electric Corporation, Industrial X-ray Section, 2519 Wilkens Avenue, Baltimore 3, Maryland.

J-08265

WESTINGHOUSE

INDUSTRIAL X-RAY

When a steel order goes through a mill, customers have a big advantage when everyone concerned with production decisions is handy and available. Inland's size and location mean that prompt personal attention can be given to every customer's problem as it comes up.

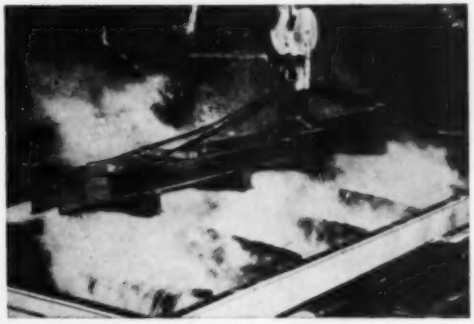
INLAND

INLAND STEEL COMPANY
38 South Dearborn Street, Chicago 3, Illinois

SALES OFFICES: Chicago, Milwaukee, St. Paul, Davenport, Kansas City, St. Louis, Indianapolis, Detroit, New York

Descaling 5 tons of stainless wire *IN 15 MINUTES* with VIRGO® Descaling Salt

10-MINUTE IMMERSION in molten bath of Virgo Descaling Salt at 900°F. loosens scale. The bath is self-regenerating, and produces no toxic fumes. Immersion time and temperature are flexible, need not be watched closely.



WATER QUENCH removes much of the loose scale. The steam generated by immersing the hot metal in the water further loosens scale by its blasting action. The work is thus prepared for the final acid dip.

THREE-MINUTE DIP in dilute acid removes the now soluble scale. The work is ready for a rinse or hosing to wash off the acid. **Result: a chemically clean surface—no pitting, etching or metal loss. TOTAL TIME—15 MINUTES.**

VIRGO DESCALING SALT—Producers and fabricators of stainless and alloy steels use Virgo Descaling Salt to quickly, positively remove scale produced by hot rolling, forging, extruding, casting, annealing.

VIRGO MOLTEN CLEANER—quickly, positively desands and degraphitizes castings; removes grease, dirt, chemicals, paint, enamel; rubber, atmospheric corrosion and other impurities.

This process can be used on steel; castings; forgings; fabricated parts; material to be salvaged. It employs simple equipment, and is easily adapted to your production methods.

SEND FOR THESE BULLETINS—Get the whole story on Virgo Descaling Salt and Virgo Molten Cleaner—what they are, how they work, their advantages, how they fit your operations, and the Hooker services you enjoy as a user of the process. Send for these bulletins today.

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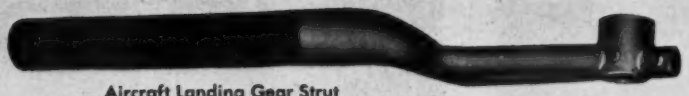
NATIONAL FORGING MACHINES
For Deep-Piercing and Upsetting!



Aircraft Landing Gear Strut

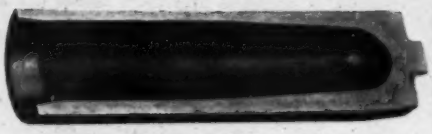
Cluster Gear

Truck Brake Spider

Aircraft Cylinder Head

Diesel Generator Quill

Shell Nose



Shell Body (Half Section)

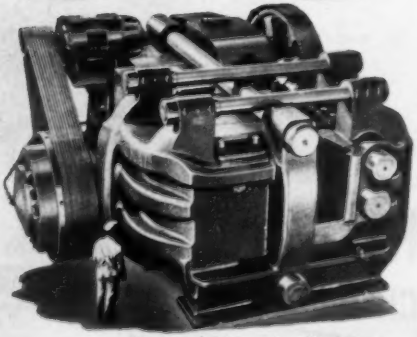
Aircraft Cylinder Barrel

Diesel Cylinder Liner

Aircraft Propeller Shaft

In World War II, the art of deep-piercing in Forging Machines came into its own. Forgings previously thought "impossible" were made routine by the pressing demands of war.

NATIONAL'S engineers and machines were "in the thick" of this forging development. Forgemen *still* choose NATIONAL Forging Machines for their difficult work . . . and *still* rely upon NATIONAL for assistance with their problems.

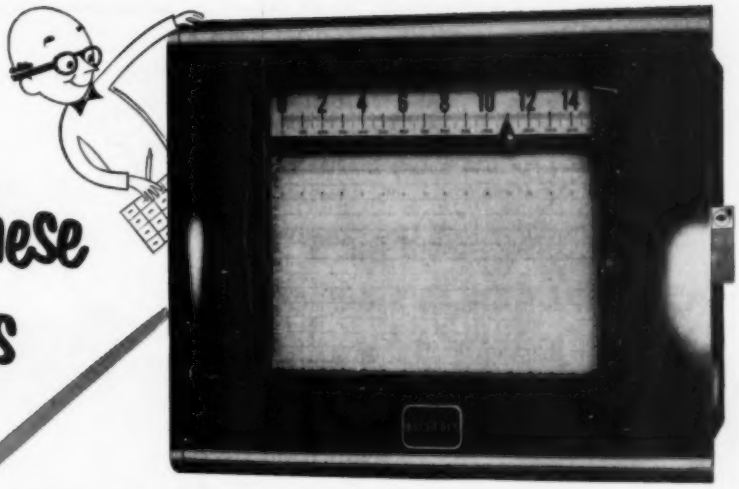


National 9" Forging Machine

NATIONAL
MACHINERY COMPANY
TIFFIN, OHIO.

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES—MAXIPRESSES—COLD HEADERS—AND BOLT, NUT, RIVET, AND WIRE NAIL MACHINERY

Hartford Detroit Chicago



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—the electronic master-mind for your temperature measuring, recording and controlling problems

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FOR DETAILED PROOF *of the sensitivity, versatility and reliability of the electronic Dynamaster, use the coupon or write for Catalog P1245.*

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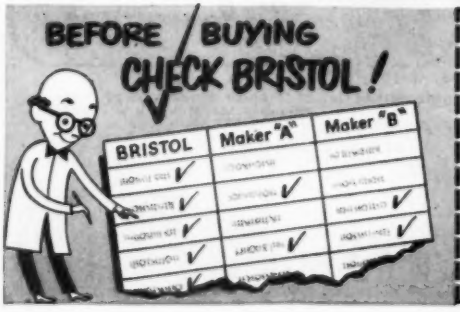

THE BRISTOL COMPANY
106 Bristol Road
Waterbury 20, Conn.

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Buehler...

...OFFERS A COMPLETE LINE OF EQUIPMENT FOR THE Metallurgical Laboratory

Buehler specimen preparation equipment is designed especially for the metallurgist, and is built with a high degree of precision and accuracy for the fast production of the finest quality of metallurgical specimens.

1. No. 1315 Press for the rapid moulding of specimen mounts, either bakelite or transparent plastic. Heating element can be raised and cooling blocks swung into position without releasing pressure on the mold.

2. No. 1211 Wet power grinder with 3/4" hp. ball bearing motor totally enclosed. Has two 12" wheels mounted on metal plates for coarse and medium grinding.

3. No. 1000 Cut-off machine is a heavy duty cutter for stock up to 3-1/2". Powered with a 3 hp. totally enclosed motor with cut-off wheel, 12" x 3/32" x 1-1/4".

4. 1505-2AB Low Speed Polisher complete with 8" balanced bronze polishing disc. Mounted to 1/4 hp. ball bearing, two speed motor, with right angle gear reduction for 161 and 246 R.P.M. spindle speeds.

5. No. 1700 New Buehler-Waisman Electro Polisher produces scratch-free specimens in a fraction of the time usually required for polishing. Speed with dependable results is obtained with both ferrous and non-ferrous samples. Simple to operate—does not require an expert technician to produce good specimens.

6. No. 1410 Hand Grinder conveniently arranged for two stage grinding with medium and fine emery paper on twin grinding surfaces. A reserve supply of 150 ft. of abrasive paper is contained in rolls and can be quickly drawn into position for use.

7. No. 1400 Emery paper disc grinder. Four grades of abrasive paper are provided for grinding on the four sides of discs, 8" in diameter. Motor 1/3 hp. with two speeds, 575 and 1150 R.P.M.

8. No. 1015 Cut-off machine for table mounting with separate unit recirculating cooling system No. 1016. Motor 1 hp. with capacity for cutting 1" stock.

THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

Buehler Ltd.
A PARTNERSHIP

METALLURGICAL APPARATUS
165 WEST WACKER DRIVE, CHICAGO 1, ILL.

TYPICAL RESULTS OF BRIGHT, SCALE-FREE WORK THE "IPSENWAY"

1. CLUTCH PRESSURE PLATE
Carbonitrided, 300 per heat, to case depth of .005" — .007" in cycle time of 60 minutes.

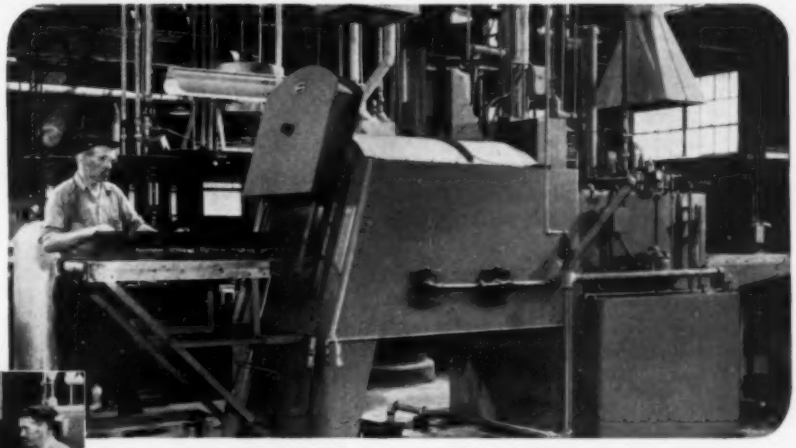
2. BREATHER VALVE GEAR
Carbonitrided, 250 pieces per heat, to case depth of .010" — .012" in cycle time of 95 minutes.

3. FENDER HINGE SEGMENT
Carbonitrided, 750 pieces per heat, to case depth of .010" — .012" in cycle time of 90 minutes.

4. ROLLER TAPPET ASSEMBLY
Carbonitrided, 800 pieces per heat, file hard case, in cycle time of 60 minutes.

PRODUCTION SHORT-CUTS *in Heat Treating*

AT HARLEY-DAVIDSON MOTOR CO., MILWAUKEE



View of Ipsen T-250 Unit in operation at Harley-Davidson. Loading door is hydraulically operated by foot pedal. Trays are transferred from heat through intermediate door into quench or cooling chamber automatically.

Unloading view showing parts after oil quenching operation. Oil is automatically circulated and temperature controlled, assuring uniform cooling throughout load.

...with an IPSEN Standard AUTOMATIC HEAT TREATING UNIT

Illustrated above are typical heat treating results obtained by Harley-Davidson Motor Co., Milwaukee, in processing parts automatically in a standard Ipsen Heat Treating and Quenching Unit. Individual methods are applied for each part to suit material and depth of hardness desired. The operation in the Ipsen is automatically controlled from heat through quench (or cooling) so that highly uniform, dependable results are obtained from batch to batch.

Acid Cleaning and Extra Handling Eliminated

Because each load is heat-treated at a uniform temperature and in a controlled and sealed atmosphere condition, the work comes out bright and scale-free. This, in turn, eliminates acid cleaning operations and extra handling. In addition, clean working conditions prevail, and unskilled operators can be quickly and easily trained to tend several units simultaneously. Investigate this modern, simplified method of heat treating today.

Write **TODAY FOR MORE FACTS**

Ask for free bulletins and find out how Ipsen Units can be applied to your work. If you wish, samples of your work will be run, procedures established, and production estimates made without obligation.

IPSEN INDUSTRIES, INC., 723 South Main Street, Rockford, Illinois

Production units for CARBONITRIDING · CARBURIZING · HARDENING · BRAZING · MARTEMPERING

AT E. C. ATKINS & CO.

A Lindberg Induction Heating Unit brazes carbide tips on circular saws

E. C. Atkins & Co., Indianapolis, Indiana, manufacturer of saws has joined the long list of companies using Lindberg Induction Heating Equipment. Atkins uses a 5 KW unit plus a specially designed fixture to braze carbide tips on large circular saws.

This unit as well as many other Lindberg units in all sections of the country are piling up good production records . . because they are ruggedly engineered and built to minimize irritating breakdowns and expensive work stoppages.

These construction features tell an important part of the story:

Conditioned cooling . . Temperature controlled water cooling eliminates condensation on high voltage parts.

Checklites . . A system of indicating lamps instantly reveals any abnormal operating conditions . . simplifies servicing.

Work coil burn-out protection . . An electrical interlock system makes it impossible to turn on power when cooling water is not flowing.

Long-life industrial tubes feature shortened internal structure . . Kovar metal-to-glass seals . . heavy walled anodes.

Sealed tank capacitors are hermetically sealed against dirt and dust . . require no servicing or refilling.

For your production brazing, soldering, hardening, annealing, stress relieving, hot forming, forging or shrink fitting requirements, investigate Lindberg Induction Heating Units. Ask for Bulletin 1440.

LINDBERG

HIGH FREQUENCY DIVISION

LINDBERG ENGINEERING COMPANY,
2450 West Hubbard Street, Chicago 12, Illinois

What does it take to *follow through?*

CRACK! Swung with perfect coordination, a clubhead hits a golf ball so hard it flattens it. You see in this A. G. Spalding & Bros. photo the swinging of a golf iron taken at a speed of 1/50,000 of a second.

It takes more than muscle to hit a golf ball the way you should. It takes coordination.

Ask anybody. Everybody will agree, just as everybody agrees you need coordination to run a business. Especially, we think, a steel mill.

Making steel is complicated enough anyway, and today we're trying to make the kinds and qualities of steel you want, and still fulfill military requirements and government allocations. Under somewhat trying circumstances.

That's why coordination of departments is the No. 1 Rule here at Wisconsin Steel. It's more than just something to pay lip service to. It's our way of life.

It enables us to keep on top of our commitments—to make only promises we can keep, and to follow through on any promises we make. Worth bearing in mind—next time you order steel.

WISCONSIN STEEL COMPANY, Affiliate of INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue, Chicago 1, Illinois

INTERNATIONAL HARVESTER

WISCONSIN STEEL

HEADQUARTERS FOR HEAVY STEEL FORGINGS

STEEL ROLLS

PRESSURE VESSELS

PRESS CYLINDER

RINGS

Whatever your needs for heavy steel forgings in industry, Midvale can assure you of the finest in craftsmanship, precision and ultimate performance. Whether it is weldless gear rings for turbine speed reduction . . . cylinders for hydraulic presses . . . weldless high-pressure vessels for oil refining, gas reactions and steam generation or hardened and ground steel rolls for cold rolling carbon and alloy steel, stainless steel, aluminum, copper, brass, zinc, foil, paper, linoleum, plastics and rubber . . . Midvale engineers can help you design them. Midvale craftsmen, with the most modern equipment, will build them to your most exacting specifications. Put your heavy forging problems in our hands.

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NICETOWN, PHILADELPHIA, PENNA.

OFFICES: NEW YORK • CHICAGO • PITTSBURGH
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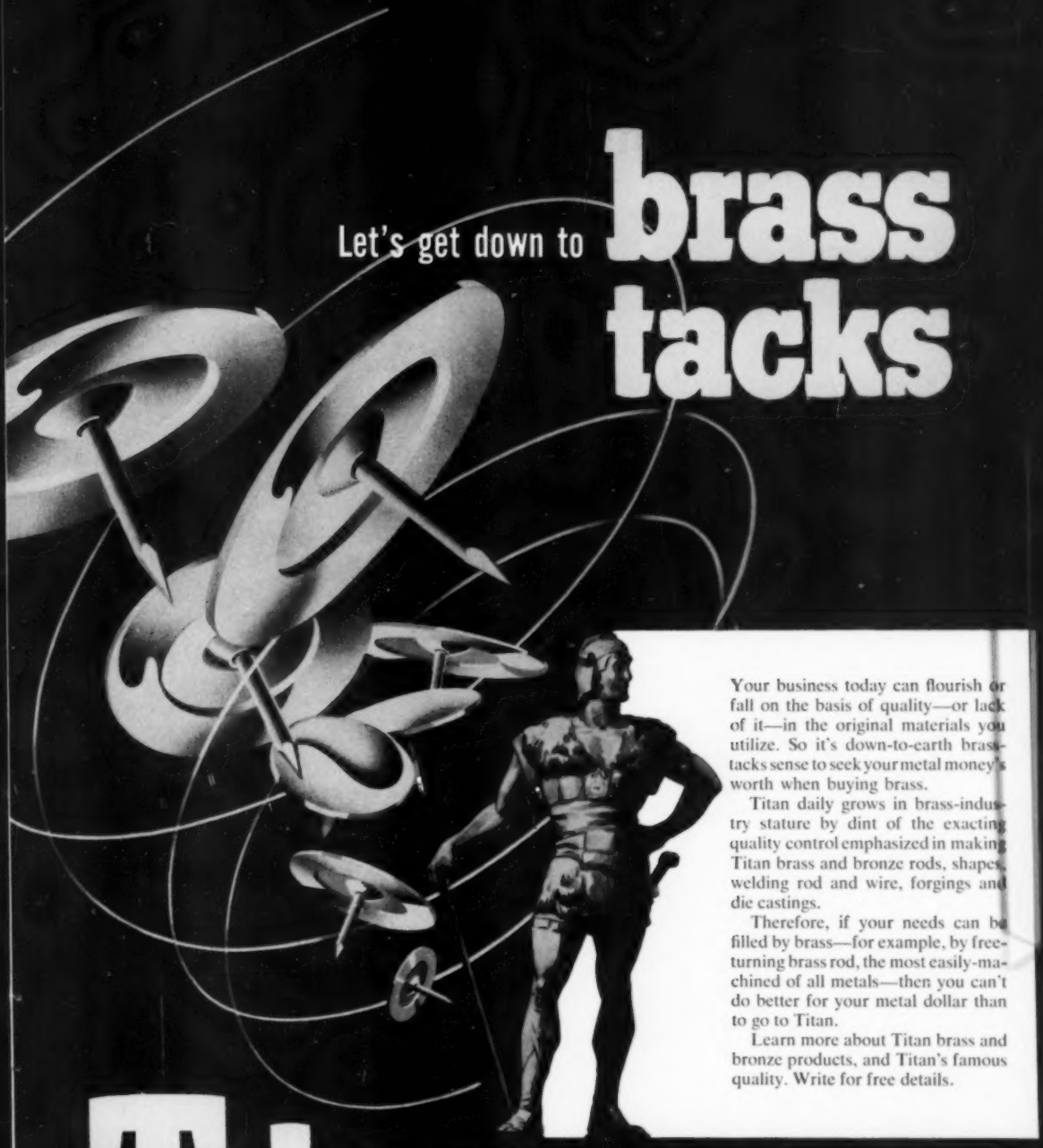
MIDVALE

Custom Steel Makers to Industry

PRODUCERS OF FORGINGS, ROLLS, RINGS, CORROSION AND HEAT RESISTING CASTINGS

Let's get down to **brass tacks**



Your business today can flourish or fall on the basis of quality—or lack of it—in the original materials you utilize. So it's down-to-earth brass-tacks sense to seek your metal money's worth when buying brass.

Titan daily grows in brass-industry stature by dint of the exacting quality control emphasized in making Titan brass and bronze rods, shapes, welding rod and wire, forgings and die castings.

Therefore, if your needs can be filled by brass—for example, by free-turning brass rod, the most easily-machined of all metals—then you can't do better for your metal dollar than to go to Titan.

Learn more about Titan brass and bronze products, and Titan's famous quality. Write for free details.

Titan

METAL MANUFACTURING COMPANY

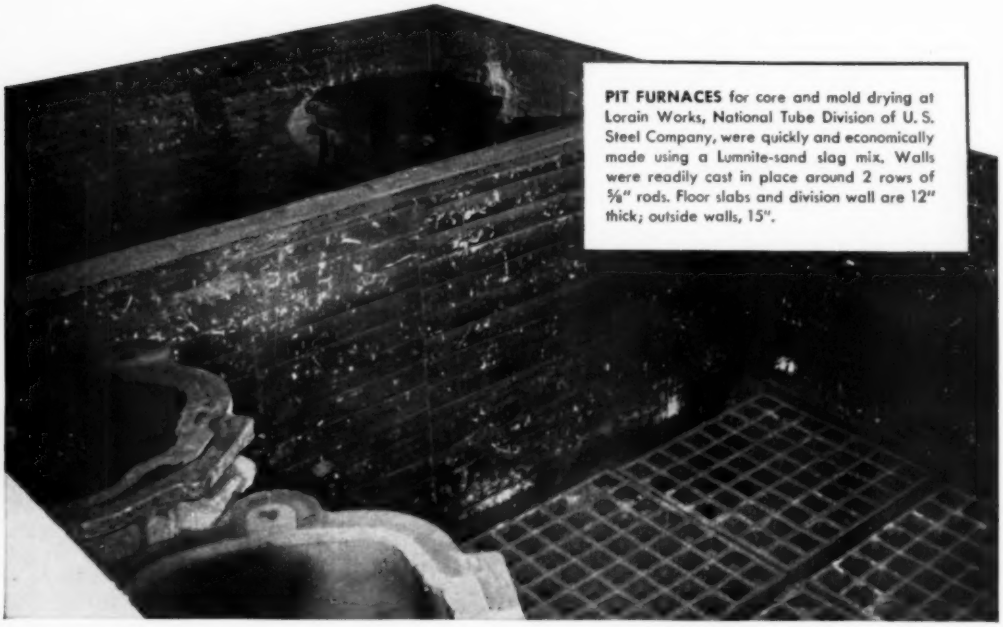
Bellefonte, Pa. Offices and Agencies in Principal Cities

Quality Alloys by Brass Specialists

RODS · FORGINGS · DIE CASTINGS

WELDING RODS · WIRE

Heat Resistant Concrete in pit furnaces still sound after two years' hard use



PIT FURNACES for core and mold drying at Lorain Works, National Tube Division of U. S. Steel Company, were quickly and economically made using a Lumnite-sand slag mix. Walls were readily cast in place around 2 rows of ⅝" rods. Floor slabs and division wall are 12" thick; outside walls, 15".

THESE PIT FURNACES for core and mold drying get bumped and nudged as heavy multi-ton core molds are hoisted in and out. In addition, the Lumnite Concrete is subjected to heating-cooling cycles that damage regular concrete. But over 2 years' continuous service to date proves that Heat-Resistant Concrete made with Lumnite can take it!

Lumnite Concrete has low volume change needed to withstand periodic heating-cooling cycles and thermal shock. Also there are no small units or joints in smooth monolithic construction which could be loosened by either periodic heating or catching projections on the huge molds.

Lumnite Concrete saves time and money from the start. One-piece walls are simply cast in place or "shot" on by cement gun. And Lumnite Concrete reaches service strength in 24 hours or less. So construction or repairs go *fast*.

This speed and economy pays off on many other jobs. Make heat-resistant, refractory or insulating refractory concrete (to 2600°F. service) simply by using a suitable aggregate and Lumnite calcium-aluminate cement.

FOR CONVENIENCE—use castable refractory mixes of Lumnite and selected aggregates to meet specific temperature and insulation requirements. Made by manufacturers of refractories and sold by their dealers. For more information write: Lumnite Division, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

""LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

MP-L-67

ATLAS® **LUMNITE for INDUSTRIAL CONCRETES**

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

A UNIVERSAL ATLAS PRODUCT

"THE THEATRE GUILD ON THE AIR"—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings—September to June*

NOW! 3-way action against FINGERPRINT DAMAGE to precision steel parts

GULF NO-RUST F.P.R.

- displaces fingerprint moisture
- neutralizes perspiration acid
- lays down temporary rust preventive film

Precision metal parts can lose some of their precision as a result of an ordinary fingerprint. The moisture and acid corrode the polished surface, interfere with smooth operation.

Gulf's new fingerprint remover eliminates this cause of lost accuracy in precision-built mechanisms. Called Gulf No-Rust F.P.R., it displaces fingerprint moisture on metal, neutralizes perspiration acid, and lays down a temporary rust preventive film.

Gulf No-Rust F.P.R. may be applied by dipping, flooding, or spraying to steel, brass, copper, and other metal surfaces. It is readily removed with Gulf Stoddard Solvent or similar petroleum solvents.

Gulf No-Rust F.P.R. is one of a complete line of Gulf quality rust preventives from which you can select the proper protective coatings to meet all your requirements. A Gulf Sales Engineer will be glad to cooperate with you in the solution of your rust and corrosion problems. Write, wire, or phone your nearest Gulf office today.

Gulf Oil Corporation · Gulf Refining Company
Pittsburgh 30, Pennsylvania

GULF SERVES INDUSTRY

These Metalworking Methods Save Time and Money

These six methods for keeping production geared to current demands are typical of the many processes and products available through LINDE. Not shown, but equally available to LINDE customers, is the invaluable combination of knowledge, technical skills, and wide practical experience that makes such developments possible.

Whatever you do with metals, there is a good chance that LINDE know-how, show-how, and equipment can help you do it better, quicker, or cheaper. Telephone or write our nearest office today.

LINDE AIR PRODUCTS COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
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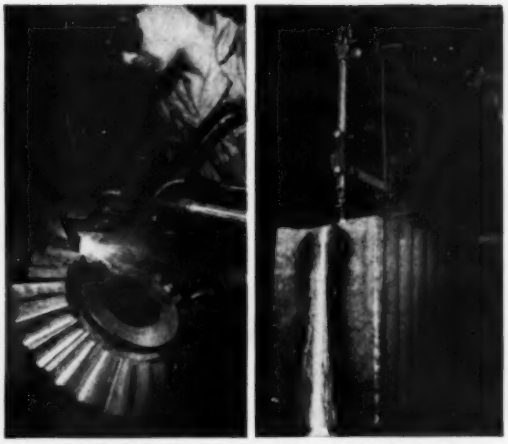
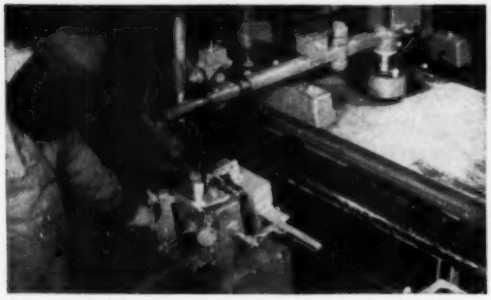
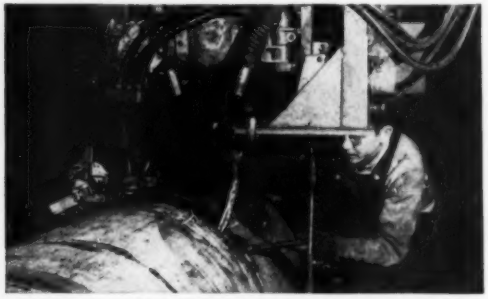


(Left) Flame-hardening gives added service life to parts by providing a hard, wear-resisting surface on a tough, ductile core. (Right) Oxygen-cutting equipment easily slices steel up to 60 in. thick. A 30-in. cut through this 45-in. thick ingot took only 15 minutes.



HELIARC welding in a protective shield of argon or helium gas easily joins hard-to-weld metals such as aluminum, magnesium, stainless steel, and copper alloys. Absence of flux and spatter reduces cleanup and finishing costs.



UNIONMELT welding, a mechanized electric process, joins metals of any thickness without sparks, spatter, smoke, or flash. Welding speeds as much as twenty times greater than by other similarly applicable methods are common.

Powder-scarfing halves conditioning costs on stainless steel. One 8-hr. shift, using two blowpipes, easily powder-scarfs 22 to 24 ingots of 1,000 lb. each.

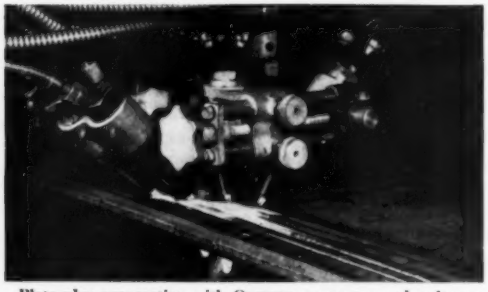


Plate-edge preparation with OXWELD apparatus makes it possible to cut steel plate to size and bevel the edges for welding in one, quick, oxygen-cutting operation.

Linde
Trade-Mark

Products and Processes for MAKING, CUTTING, JOINING, TREATING, AND FORMING METALS

The terms "Heliarc," "Linde," "Oxweld," and "Unionmelt" are registered trade-marks of Union Carbide and Carbon Corporation

25 "Production Headaches" Avoided with RF HEATING!

These 25 tractor parts posed quite a problem to International Harvester's new Louisville Works. Each one had to be hardened—quickly, efficiently, economically. Each one could have been a "production headache"!

Management conferred, studied and carefully investigated the problem. This analysis, coupled with their past experience, led to the final decision. The choice for these parts . . . Induction Heating!

Westinghouse equipment was purchased with the following results:—reduced heating, machining, and steel costs . . . lower material handling costs . . . and better quality with lower product design costs. All this with only one 50 KW-450 KC and four 20 KW-450 KC Westinghouse RF units!

If you're the kind of alert businessman who is always on the lookout for increased production at decreased costs, look into the possibilities of Westinghouse Induction Heating.

The full Induction Heating story, complete with case histories, is told in a highly interesting booklet. Just send in the coupon for your free copy!

J-02242

Westinghouse Electric Corporation
Department P-42
2519 Wilkens Avenue · Baltimore 3, Maryland

Send me your informative case history booklet on induction heating.

Name ..... Position .....

Company .....

Street .....

City ..... Zone ..... State .....

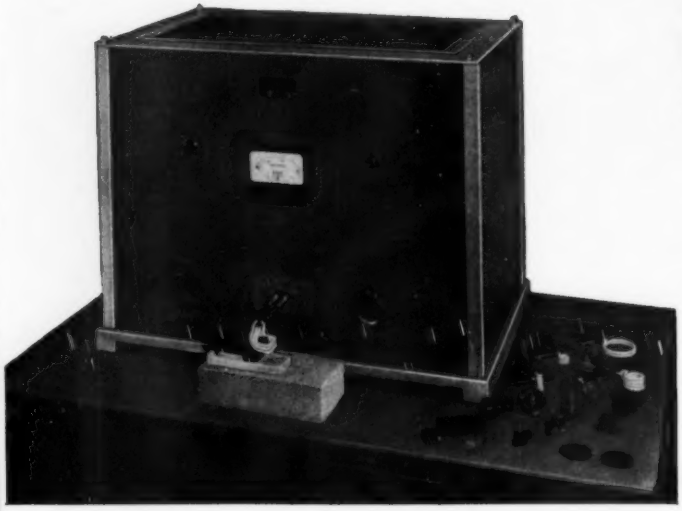
YOU CAN BE SURE... IF IT'S

Westinghouse

INDUCTION HEATING

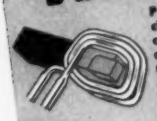
Lepel *presents*

A *Low Cost* PORTABLE HIGH FREQUENCY *Induction* HEATING UNIT



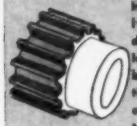
BRAZING

Permits widest choice of silver or copper brazing alloys from lowest to highest melting points. Ideal for brazing carbide tips.



HARDENING

Heat localized exactly where wanted at desired temperature. Ideal for gears, cams, bearing surfaces, cutting tools and other areas that are subject to wear.



SOLDERING

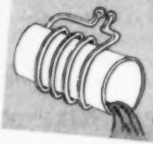
Speedily and neatly performs intricate soldering applications with or without the use of pre-formed rings.

ANNEALING

Ideal for annealing, stress-relieving, normalizing or pre-heating selected areas.

MELTING

Readily melts quantities of ferrous and non-ferrous metals in either graphite or ceramic crucibles.



- **SMALL AND COMPACT** Conveniently operated on bench or table—no mounting necessary.
- **ECONOMICAL OPERATION** No special power installation required. Operates on 110 volts, 60 or 50 cycle line at unity power factor.
- **FULLY GUARANTEED** Guaranteed for continuous duty cycle and stated performance.

This versatile unit is priced so low that every shop may now take advantage of modern induction heating techniques to improve quality and to increase production. Its simplicity of operation eliminates the need for skilled personnel.

The Lepel Model 2 KW will meet the requirements of machine shops, toolrooms, research laboratories and educational institutions. It is especially suitable for hardening, brazing and soldering small parts of either ferrous or non-ferrous metals.

Complete unit with line connection and load coil.

$870.
f.o.b. factory

WILL HEAT TO 1500° F.

⅛"	steel	rod	1"	length	in	approx.	1 second
¼"	"	"	"	"	"	"	3 seconds
½"	"	"	"	"	"	"	15 seconds
1"	"	"	"	"	"	"	60 seconds

Will melt 4 ounces of brass or steel in 4 minutes.
Equally well suited for heating of non-ferrous metals.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

Write for Lepel Catalog MP-8

More "16-25-6" used in jet engine rotor wheels than all other alloys combined!

"16-25-6" was first developed by the Timken Company during World War II. The *one* steel that could be produced commercially for jet engine rotors, it helped make jet propulsion practical.

Today, more "16-25-6" goes into solid and composite jet engine rotor wheels than all other super-alloy steels combined! That's because "16-25-6" has the *best* combination of the three top requirements for jet engine rotors: 1) It has good high temperature properties. Operating at temperatures up to 1500° F., it retains high creep and stress rupture strength. And it has excellent resistance to scale and corrosion. 2) It is relatively low in strategic alloys. "16-25-6" uses none of the highly strategic alloys, contains no cobalt or columbium. 3) It has good machinability.

"16-25-6" is the ideal alloy steel for today's high temperature, high speed applications. Why not put the Timken Company's wide experience in high temperature steels to work for you? We'll help you adapt "16-25-6" to your purposes—or help you pick other alloy steels suited to your needs. Write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Cut Manual Handling Time

WITH *Light Weight*
PSC ANNEALING CONTAINERS

Because they weigh up to 2/3 less than cast containers, PSC welded alloy annealing units obviously handle much easier and faster. Let us show you how installations are effecting impressive savings in labor costs alone.

Left top, light-weight box with sand seal construction for bright annealing. Left bottom, special basket for aircraft parts; movable sides and trays. Right top, annealing tubes for steel mills. Only ¼" alloy; years of service. Right bottom, combination annealing and pickling rack. Top braces removable.

In addition to the savings in handling time, PSC light-weight annealing containers effect four other substantial economies. First, being so much lighter in weight, they attain pot heat in less time; PSC installations have shortened heating cycles as much as 5 hours. Second, fuel savings; a recent study showed a $40 saving per anneal. Third, being less bulky, PSC units increase furnace capacity. Fourth, their much longer service life cuts replacement costs.

Standard and Special Types for Every Purpose

PSC welded alloy heat-treating equipment is furnished in any size, design or metal specification: annealing and carburizing boxes, covers, baskets, racks, tubes, retorts, etc. As a pioneer of welded alloy units, we offer a wealth of experienced engineering assistance. Send blue prints or write as to your needs.

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

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HARDENING TIME CUT 62%

with TOCCO* Induction Heating

When minutes saved mean dollars earned, look to TOCCO Induction Heating

• Singer Manufacturing Co., makers of famous Singer Sewing Machines, reports the following results when they switched to TOCCO—hardening the shaft assemblies shown above. Note the operations eliminated through the use of TOCCO and the savings of 151.8 minutes per 100 parts.

OLD METHOD		TOCCO METHOD	
Operation	Min./100 Pcs.	Operation	Min./100 Pcs.
Assemble on plating racks	23.0	eliminated	
Copper plate crank end	43.0	eliminated	
Remove from plating racks	15.0	eliminated	
Harden shaft and anneal crank	120.0	TOCCO harden and clean	92.5
Strip lead	10.0	eliminated	
Strip copper and clean	33.3	eliminated	—
Old method total time	244.3 minutes	TOCCO method total time	92.5 minutes

Have you investigated TOCCO's time and cost savings possibilities for your hardening, brazing, forging or melting operations? It will pay you to write or send blueprints of your parts for analysis—no obligation of course.

SEE OUR CATALOG IN

THE OHIO CRANKSHAFT COMPANY • CLEVELAND 1, OHIO

TOCCO

Induction Heating Equipment must meet the requirements of the Federal Communication Commission's Rules and Regulations Relating to Industrial, Scientific and Medical Services, Part 18. All TOCCO equipment is certified to comply with these rules and regulations.

How Much is a Good Spring Worth?

Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.

Valves faced with Alloy 717 stand up under high temperatures and the corrosive action of hot exhaust gases.

Hoskins Chromel-Alumel thermocouple alloys accurately register exhaust temperatures of jet aircraft engines.

Springs are rather commonplace things . . . used in all sorts of products to perform all sorts of functions. So taken-for-granted are they, in fact, that the only time you really appreciate their worth (or lack of worth) is when they fail to do the job they're supposed to do.

And that's where Hoskins Alloy 769 really comes into its own. Because here is a *special* alloy that possesses some *very special* spring characteristics. For example, it's highly resistant to atmospheric and chemical corrosion. It has exceptional resistance to set and fatigue, which enables it to provide more constant delivery of torque over longer periods of time than ordinary spring material. It's non-magnetic, hard, and strong. Yet it can be cold-formed, heat-treated under controlled conditions, and welded, soldered, or brazed. What's more, it retains its desirable spring properties from sub-zero temperatures up to about 750° F.

Alloy 769 is only one of several special purpose alloys produced by Hoskins. Among the others: the Chromel-Alumel thermocouple alloys . . . unconditionally guaranteed to register true temperature-e.m.f. values within close specified limits. Alloy 717 . . . for facing engine valves; Alloy 502 . . . widely used for heat resistant mechanical applications. Plus special spark plug electrode alloys which have long been the accepted standards for quality and durability. And, of course, there is Hoskins Chromel . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products for home and industry.

HOSKINS

MANUFACTURING COMPANY

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Chromel® NICKEL CHROMIUM WIRE

"no more GAMBLING on tool steel selection"

[½ actual size; Selector is in 3 colors]

That's what one of the thousands of pleased users says about his CRUCIBLE TOOL STEEL SELECTOR, the new, simple, handy method of picking the right steel, *right* from the start. Since Crucible announced this Selector two years ago, thousands of tool steel users have received their Selectors . . . and here's what some of them say—

"Handiest selector I've ever seen!"
"Saves me time and headaches"
"It's so logical—you begin with the application".

You can be sure the answer you get with your Crucible Tool Steel Selector will be just right in every case, for this Selector covers 22 tool steels which fit 98% of all tool steel applications. And when—with a flip of the round dial—you get the answer, you'll get the steel FAST, too, because all the tool steels on the Selector are right in stock, in all our 26 conveniently-located warehouses.

This Selector is bound to be a big help to you—so write for yours today. There is no obligation whatsoever. Just fill in the coupon and mail now . . . before you turn this page and forget! CRUCIBLE STEEL COMPANY OF AMERICA, Chrysler Building, New York 17, New York.

Here's how it works:

To use the Selector, all you need know is the characteristics that come with the job: type and condition of material to be worked, the number of pieces to be produced, the method of working, and the condition of the equipment to be used.

FOUR STEPS—and you've got the right answer!

1. Move arrow to major class covering application
2. Select sub-group which best fits application
3. Note major tool characteristics (under arrow) and other characteristics in cut-outs for each grade in sub-group
4. Select tool steel indicated

That's all there is to it!

Here's an example:

Application—Deep drawing die for steel

Major Class—Metal Forming—Cold

Sub-Group—Special Purpose

Tool Characteristics—Wear Resistance

Tool Steel—Airdi 150

One turn of the dial does it!

And you're sure you're right!

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Dept. MP, Chrysler Building, 405 Lexington Avenue
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These stainless steel impeller shafts are manufactured from Free-Machining ENDURO, Type 416, by The Deming Company, Salem, Ohio. In the photo above, a Deming Centrifugal Pump is shown pumping brine in a packing house.

ENDURO Makes Close-Tolerance Shafts Corrosion-Resistant

Shafts for Deming Centrifugal Pumps must have high tensile strength. They must resist corrosion, as they often are in contact with brine, solvents, waste, and other corrosive solutions. They must resist abrasion and wear.

Since close tolerances are absolutely essential, the shafts must be accurately machined—at reasonable unit cost.

A big order. Yet, Free-Machining ENDURO Stainless Steel meets all these shaft requirements.

Free-Machining ENDURO Bars are cold-finished by Republic's Union Drawn Steel Division to provide close tolerances, accuracy of section, uniform soundness and fine surface finish . . . plus the high physical and chemical properties of stainless steel. *Two grades are 90% as machinable as Bessemer screw stock!*

Free-Machining ENDURO also is available in hot rolled bars, and in wire. Republic metallurgists are ready to give prompt assistance on applications, processing, and use. Contact them through your Republic District Sales Office, or write:

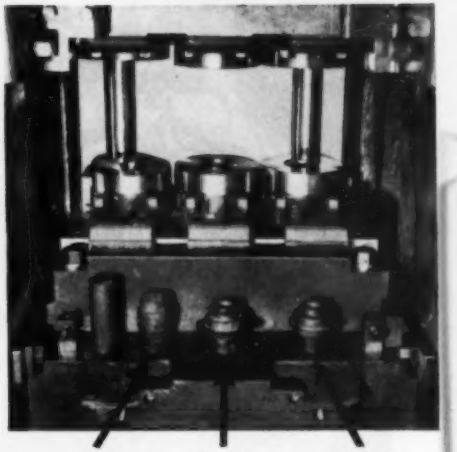
REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

Republic ENDURO® FREE-MACHINING STAINLESS STEEL

REPUBLIC STEEL

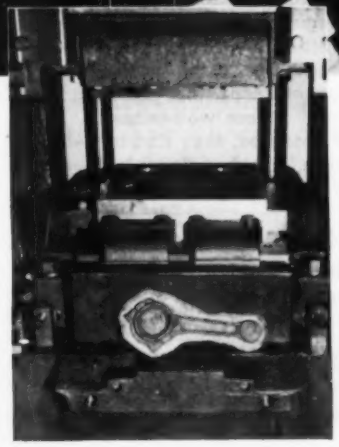
Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

FORGED IN AJAX PRESSES



BUSTER OPERATION | FINISHED FORGING | BLOCKER OPERATION

The progressive forging operations necessary for forming gear blanks for heavy trucks are shown in the foreground. Above, the dies mounted in a 1600 ton press, are in the following order: buster die on the left, blocker die on right and the finish forge die in the center. Each operation is shown in front of the die it is formed in.



Shown here are the dies and bolsters mounted in a 1600 ton press. The product, a heavy automotive connecting rod, is pictured in the foreground.

THE **Ajax** MANUFACTURING COMPANY

EUCLID BRANCH P. O. CLEVELAND 17, OHIO

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DEWART BUILDING NEW LONDON, CONN.

WRITE FOR BULLETIN 75 B

"You may have to stand outside!"

REMEMBER Aesop's fable of the camel and his master--how the kind master allowed the shivering beast to put into the tent first his head, next his shoulders, then his forelegs!

And then the camel said, "Master, I think I ought to come wholly inside," and crowded in. Immediately he said, "There is hardly room for us both, so I think it would be better for you to stand outside so I can turn around and lie down." And without further ado, the camel kicked the man out and took the entire tent.

Men have heard this story for 2,500 years--repeatedly have seen how it illustrates what happens when one man or group of men gain power over others. Men saw it happen in Italy and Germany when Mussolini and Hitler took over. Men saw it happen in Russia.

Even here in America a similar trend is evident. Powerful influences overlook no opportunity, through political manipulation, central controls and bureaucratic regulations, to intrude more and more in our private lives. The situation demands continual, alert watchfulness by all citizens who believe in individual liberty and freedom, to prevent this camel of big government from creeping further into the tent. Before we realize it, "we, the people," the master, may find ourselves "standing outside." In America it is government, which is the servant of the people.

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The Youngstown Sheet and Tube Company

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ROLOCK

FABRICATED ALLOYS

AN ASSEMBLY THAT "*Gives a Lift*" TO AN IMPORTANT HEAT TREATING JOB

Four sets of these Stacking Furnace Baskets were custom-fabricated by Rolock to fit pit-type furnaces built by Hevi Duty Electric Company. Photo at left shows bottom grid, mesh disc, lift straps and fastening keys. Photo at right shows complete assembly ready for furnace.

They are used by a nationally known manufacturer for hardening at 1850° F. Material of basket is type 330 stainless steel. Size, each basket 28" I.D. x 12¾" high. To facilitate handling in and out of the furnace the baskets are securely fastened together with alloy lift straps and keys. Note fabricated bottom grid and mesh disc. All welding is of the highest quality.

Rolock equipment is engineered to suit the specific job... for maximum strength... for as high ratio of load to weight as safety permits ...for handling convenience... and for low hour-cost through extended service life. Our engineering department likes to solve problems. Tell us about yours!

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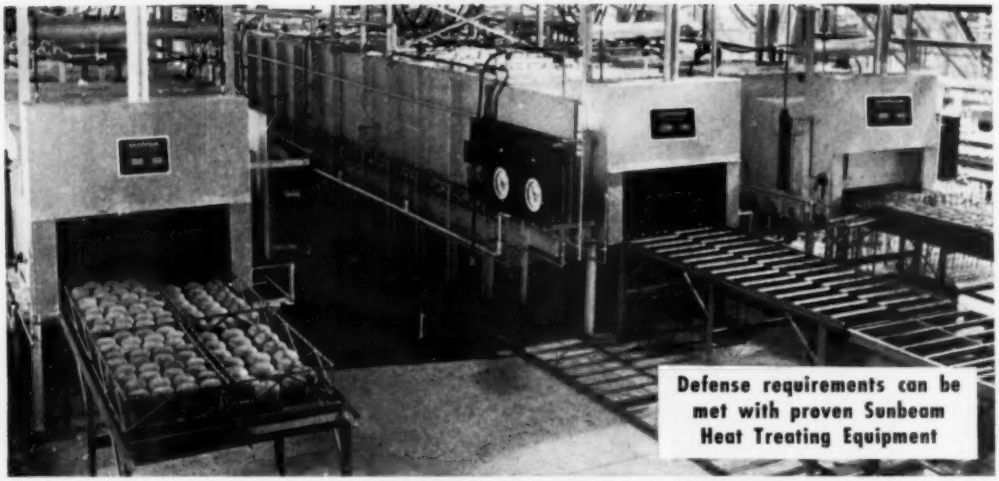
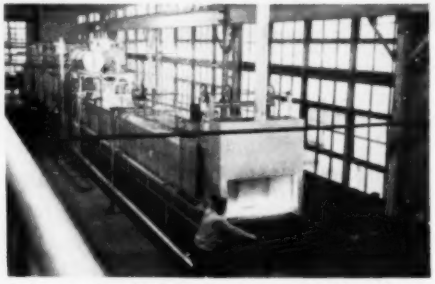
HOW SUNBEAM INDUSTRIAL FURNACES MEET THE DEMANDS ON THE PRODUCTION FRONT

ANNEALING STEEL CARTRIDGE CASES

at EKCO PRODUCTS, Massillon, Ohio



In the manufacture of 105 mm steel cartridge cases for Army Ordnance by Ekco Products, three Sunbeam electrically-heated, roller-hearth, atmosphere-controlled annealing furnaces are used for annealing the cases between the various draw press passes. As the height of work varies after each press draw operation, one unit is designated to handle a pre-determined number of sizes.



Discharge view of one of the three Sunbeam units in use at Ekco. As work becomes bulkier, during the last draw press passes, a greater furnace volume for annealing is required during the 3rd and 4th anneal as compared to the 1st and 2nd. This makes it possible to divide the work among furnaces in a volume rather than weight basis.

To fabricate large caliber steel cartridge cases for Army Ordnance by the cold drawing process at Ekco, it is essential to provide an accurate anneal between the various passes through the dies. The anneal must provide a controlled, even hardness throughout the entire cross-section of the case, starting from the cupping operation through the last drawing pass. This accurate control of hardnesses makes it possible to hold to closer size tolerances, improves surface qualities of the case, lessens the possibility of cracking during its fabrication and increases die life. Accordingly, the quality of the annealing has a direct effect on the number of acceptable cases produced.

Three Sunbeam continuous electric furnaces are used at Ekco for annealing. These are of the roller hearth design, each roller being powered throughout the heating and cooling chambers. Each unit has an effective heating space 40 ft. by 43 in. wide by 28 in. high with a cooling space 46 ft. long.

Heating elements completely surround the work throughout the entire length of the heating chamber to assure close temperature control and even heat distribution with high heating rates. Heating elements are divided into three zones, each having its own contactor and automatic temperature control equipment. The increased flexibility from three zone operation makes this equipment adaptable for annealing cases in any phase of Ekco's processing cycle. It also provides the accuracy of control necessary for correct press draw annealing.

IF YOU ARE CONSIDERING DEFENSE WORK CALL SUNBEAM. Designs are available for heat treating the following materiel:

SHELLS: 57MM; 75MM; 90MM; 105MM; 120MM; 155MM; 3", 5", 6", 8" Navy Shells (Harden, Quench and Draw).

FORGINGS: Rotary Hearth and Pusher-type Forging Furnaces.

ARMOR PIERCING SHOT (Harden, Quench and Draw).

CARTRIDGE CASES (Anneal, Stress Relieve).

MACHINE GUN CLIPS (Harden, Quench and Draw).

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A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM industrial furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM engineer will be glad to call and discuss your heat treating problems with you.

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HOW IT WORKS

A. Minor Load Penetration

B. Major Load Penetration

C. Linear measurement of penetration increase which "ROCKWELL*" converts to hardness reading

BRALE Penetrator Accuracy Is Proved in Wilson's Standardizing Laboratory

● One point of hardness on the Rockwell C scale equals .00008" so penetrator accuracy must be constant. That's why Wilson maintains its Standardizing Laboratory for testing on many test blocks and approving every BRALE penetrator.

Each BRALE is precision ground to shape under high magnification and is accurate to the degree required for a research laboratory. Wilson's BRALE Penetrator gives true readings at all points on the dial. To get the greatest accuracy from your hardness tester, see that it is equipped with a diamond BRALE penetrator.

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AMERICAN CHAIN & CABLE

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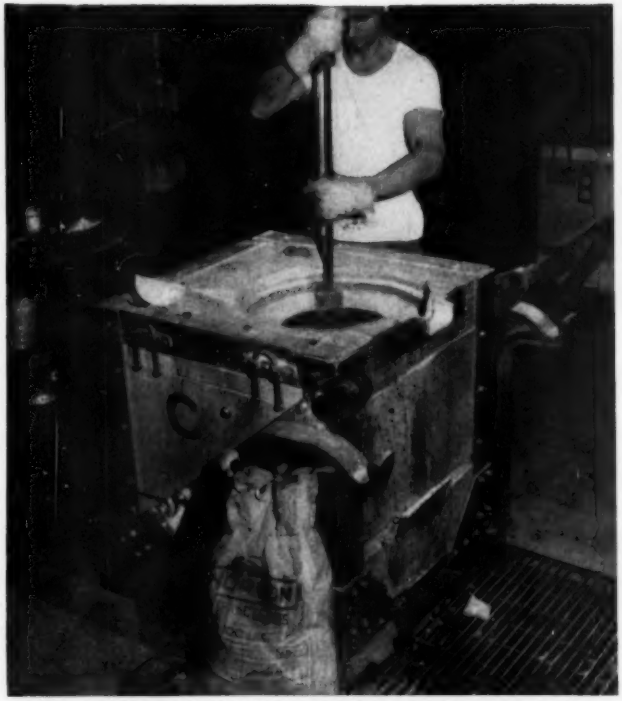
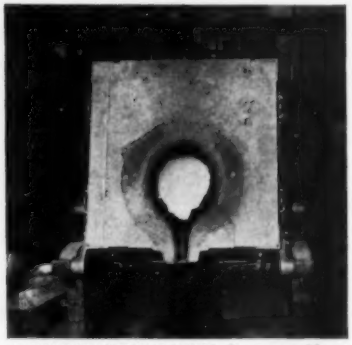


RAMMING Norton MAGNORITE cement lining into an Ajax 500-lb. high frequency induction furnace. This cement has been developed specifically to be dry rammed and will withstand temperatures up to 3250 F. It provides densest possible lining for resistance to metal penetration and erosion.

MOLTEN STEEL is here poured into ladles. Due to the employment of fractional tapping, cement lining must withstand much longer periods of holding melt at pouring temperatures. Highly refractory Norton MAGNORITE cement insures long life and low maintenance cost even under these conditions.



MAGNORITE CEMENT LINING shows no evidence of erosion or chemical attack after metal has been completely poured, thus assuring minimum repairs. This cement is designed to have a slight expansion upon maturing to eliminate shrinkage cracks which might lead to furnace failure.

Melt more metal per lining

with Norton Refractory cements

You'll get long life, low maintenance cost from your furnace linings by using Norton refractory cements. *You'll melt more metal per lining.*

These cements are available in a variety of refractory compositions designed to meet your individual needs. *Norton MAGNORITE* cement,* for instance, is used in high frequency furnaces for a wide variety of melts, ranging from straight steels to heat-resistant compositions. *Norton FUSED STABILIZED ZIRCONIA* crucibles are excellent for melting platinum and its alloys. This sensational refractory is not wetted by the metal, permitting 100% recovery of the melt without destroying the crucible. *Norton ALUNDUM* and MAGNORITE* crocks, covers, and cements are used successfully in indirect arc furnaces. These cements are also used in low frequency furnaces for melting such refractory alloys as cupro-nickel and nickel silver; high copper alloys and Al, Te, and Si bronzes. *ALUNDUM* cement is also excellent for handling stainless steel.

For heat-treating and sintering furnaces investigate ALUNDUM and CRYSTOLON* hearth plates, pier brick, burner blocks, muffles, muffle plates, skid rails, recuperator tubes, burner-tunnel, and embedding cements.

Whatever your problem, you can depend on satisfactory solution when Norton research engineers Norton refractories to fit your exact requirements. For further information, see your nearby Norton representative — or write direct to NORTON COMPANY, 325 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.

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Metal Progress

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Abstract of AEC declassified report AECD-2942, "Preparation of Crucibles From Nitrides", by L. S. Foster. Based on Report MIT-1041 written at Massachusetts Institute of Technology, July 1945 (declassified March 23, 1950).

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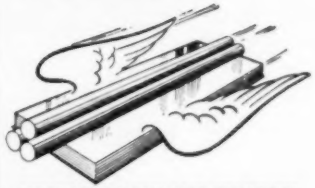

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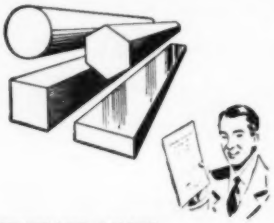
Alloy bars, sheets and strip in more than 400 sizes, finishes, conditions. Stainless in more than 300, to meet all important aircraft specs.



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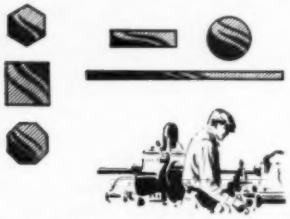
Rounds, flats, hex's, squares—hot rolled and cold finished—complete heat treatment guide with each shipment.



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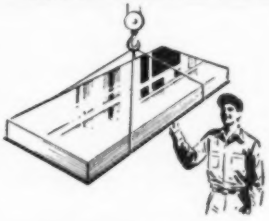
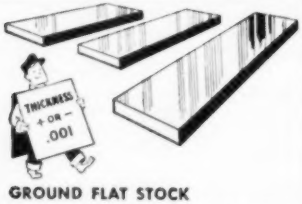


STRAIGHT CHROME STAINLESS

No allotment required for these stainless bars, plates and sheets. Can often replace restricted nickel-chrome types.



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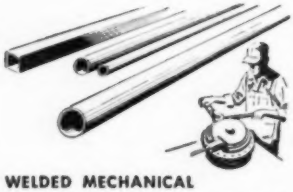

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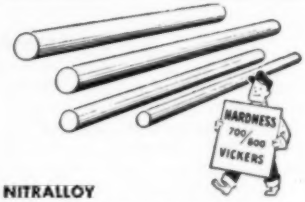

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By Lt. Col. Daniel J. Murphy, Ordnance Corps, U. S. Army
Chief of Pitman-Dunn Laboratories, Frankford Arsenal, Philadelphia, Pa.

Metallurgical Activities at Frankford Arsenal

THE METALLURGICAL activities of Frankford Arsenal stem from its function as one of the six manufacturing arsenals of the Army Ordnance Corps. It develops and manufactures small arms ammunition, fuses, shell and cartridge cases for artillery ammunition, and fire-control instruments. It is the center for gage design, for the development of recoilless rifles, and for related research.

The Pitman-Dunn Laboratories of the Arsenal, with a scientific and technical staff of more than 500, are named in honor of two research pioneers. While a laboratory existed as early as 1864, its functions became active in 1892 under Capt. John Pitman. The field was enlarged in 1896 with the addition of Capt. B. W. Dunn.

These laboratories now serve as the ordnance center for basic research on nonferrous metals and alloys, and on corrosion; for applied research on small arms ammunition, light alloy materials, armor-piercing shot, oils and lubricants, tropicalization of materials, protective finishes and treatments for metals; for the design and development of propellant-actuated devices including catapults for airplane pilots, primer and ignition systems for small arms ammunition, and recoilless rifles.

Two closely related groups conduct research and development in physical metallurgy and in engineering metallurgy. Those engaged in physical metallurgy make the theoretical approach and cover *(a)* the design of alloys — new compositions and their physical and mechanical properties, *(b)* the casting of alloys, such as melting and pouring problems, gases in metals, porosity in castings, *(c)* behavior of alloys in shaping and fabrication, and *(d)* heat treatment theory and associated effects.

The engineering metallurgy group makes the practical approach and covers *(a)* fabrication of metals, both wrought and cast methods, *(b)* joining of metals, *(c)* heat treatment methods and techniques, and *(d)* structure of metals and metallographic techniques.

For convenience of description, some of the interesting studies being carried out at the Arsenal can be grouped under the general headings of "basic metallurgical research", "process research", and "special metallurgical problems". Basic metallurgical research will be considered first.

Mechanical Metallurgy — Initial work began in 1946 on an evaluation of the curve for true stress versus natural strain for armor-piercing projectile steels. These steels are usually heat treated to such high hardness that only compression testing can be used to establish the flow curves.

To obtain instantaneous measurements while under load an accurate extensometer was required. The final design for use on steel specimens is shown in Fig. 1. Wire resistance strain gages are mounted on opposite sides of the beam-type strain member and indicate change in diameter of the specimen. After a simple calibration, the instantaneous diameter while under load may easily be determined with sufficient accuracy.

Another problem in compression testing is barreling of the side walls caused by inhomogeneous straining. Numerous foils and lubricants have been placed on the ends of specimens to reduce lateral friction; barreling was reduced considerably but not entirely. A mathematical correction factor was then developed to determine the true stress if no barreling were present. With these preliminary problems solved, data on true stress versus natural strain were obtained for numerous projectile steels, and subsequently were used in studying ballistic performance of armor-piercing shot.

Similar compression test programs for copper, brass and some aluminum alloys revealed an interesting characteristic when curves for alpha brasses are plotted on logarithmic coordinates. Previous investigators have claimed that such a plot gives two straight lines. However, the logarithmic

plot constructed with the new extensometer actually consists of an S-shaped curve, with no portion a straight line, as shown in Fig. 2.

Another phase of this program was to develop a static and a dynamic torsion testing machine that would subject the test specimen to shear stresses only. Two such machines have been constructed and may be used for subjecting any ferrous or nonferrous material to pure shear. With these a shear fracture can be obtained on steel specimens hardened to Rockwell C-66.

Coincident with this experimental work in the development and application of precision strain gages, theoretical studies have been made on crack propagation in a tensile specimen, tri-axial stress systems in highly deformed compression and tension, fracturing of armor plate in tension as a result of reflected compression stress, and effects created by vibrating metal during solidification.

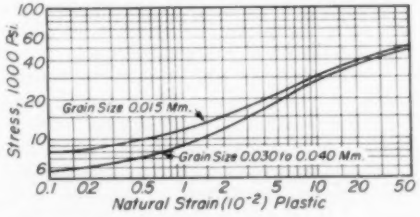
Structure of Metals — In metallography, new techniques, using electrolytic polishing and color photomicrography, are being developed. In solid-state physics, the program is concerned generally with the study of imperfections in metals, their production, motion and effects. As an example, the dislocation theory of metals has been applied to the mechanism of stress-relief annealing in alpha brass by analyzing variations of internal friction, resistivity, and Young's modulus. Photo-elastic apparatus is being utilized to study internal stresses in transparent crystalline substances and correlate their distribution and recovery with X-ray data. An ultimate objective in this category will be to predict the behavior of specimens in simple tensile tests from fundamental atomic mechanisms. An empirical analysis of the n-power law of strain hardening in simple tension is being extended to bi-axial stresses. Future work will attempt to relate the empirical formulas to fundamental properties of materials, probably in terms of dislocation theory.

Foundry Research at the Arsenal is comparatively recent, dating from a modest start in 1943 with a small nonferrous investment casting unit. Mechanical properties of investment-cast copper, aluminum, and magnesium-base alloys were investigated. A highly satisfactory wax injection machine, semi-automatic in operation, was evolved. Suction casting techniques and equipment were refined and perfected at a time when the industry was relying mainly upon centrifuging methods.

Recently an existing warehouse building has been converted into a well-rounded research and development foundry, with space for sand as well as investment casting. Gas-fired and induction melting equipment ranges from a few ounces to 150-lb. capacity. Methods and equipment for casting small parts from titanium are available. Vacuum induction, arc and other specialized melting units are housed in separate areas.

Frankford Arsenal is endeavoring to stimulate work on light metal foundry problems throughout the country, and at the present time four outside research facilities are actively cooperating. The main emphasis is on aluminum, magnesium and titanium, for these offer the greatest promise in the long-range ordnance objective to lighten battle equipment whether borne on a soldier's back or by plane.

Fig. 2 — S-Shaped Logarithmic Stress-Strain Curves of Oxygen-Free, High-Conductivity Copper in Compression



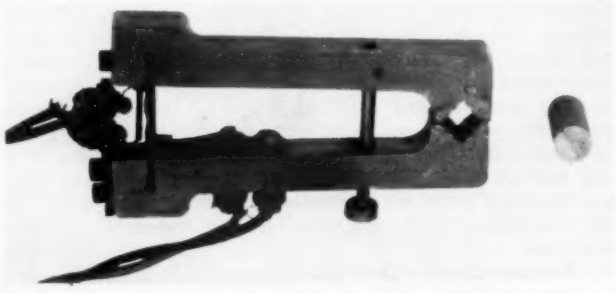


Fig. 1 — Compression Extensometer for Steel Specimens ¾ In. Diameter

Metallurgical Process Research

Under the heading of "metallurgical process research" come fabrication of metals, welding, corrosion, and heat treatment.

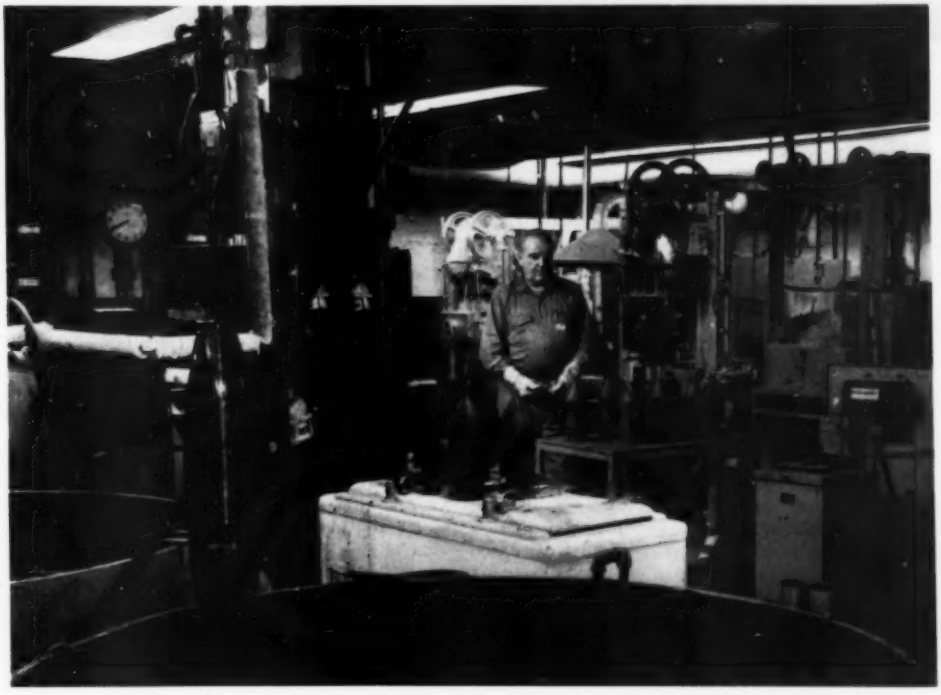
Fabrication of Metals — Equipment available includes a forging hammer, swaging machine and presses for drawing and impact extrusion in addition to the normal machine shop facilities. Among the various studies in process are the development of light alloy cartridge cases, study of high-strength magnesium alloys for a variety of structural purposes, and of the behavior of titanium under plastic deformation.

Efforts to conserve metals in critical supply are being furthered by the application of powder metallurgy to ordnance parts. The Arsenal's research program has developed a rotating band for 90-mm. shell made of sintered iron that costs about one third less than the equivalent copper or gilding-metal band, and considerably increases armor-piercing velocities. A "slider" for a mechanical time fuse made of sintered brass has virtually eliminated scrap loss, which was formerly 60% of the metal used in bar stock. This tiny item alone is estimated to save the taxpayer some half million dollars.

Many specifications for nonferrous metals used by the Ordnance Corps are drafted at the Arsenal, and those written by other government agencies are critically reviewed. Close liaison is maintained with the American Society for Testing Materials so that government specifications can be coordinated with industrial practice.

Welding Research evaluates the various joining and overlaying processes for nonferrous metals, brazing, soldering and the preparation of literature and materials specifications. A specially designed and constructed electronic control panel is probably unique. It controls the several a.c. and d.c. welding units and is of two parts so that one a.c. and one d.c. unit may be selected by a dial and operated simultaneously by push buttons. Electrical conditions of the welding action are recorded automatically. This panel eliminates rewiring for changing weld-

Fig. 3 — A Portion of the Heat Treatment Laboratory for Research on Projectiles



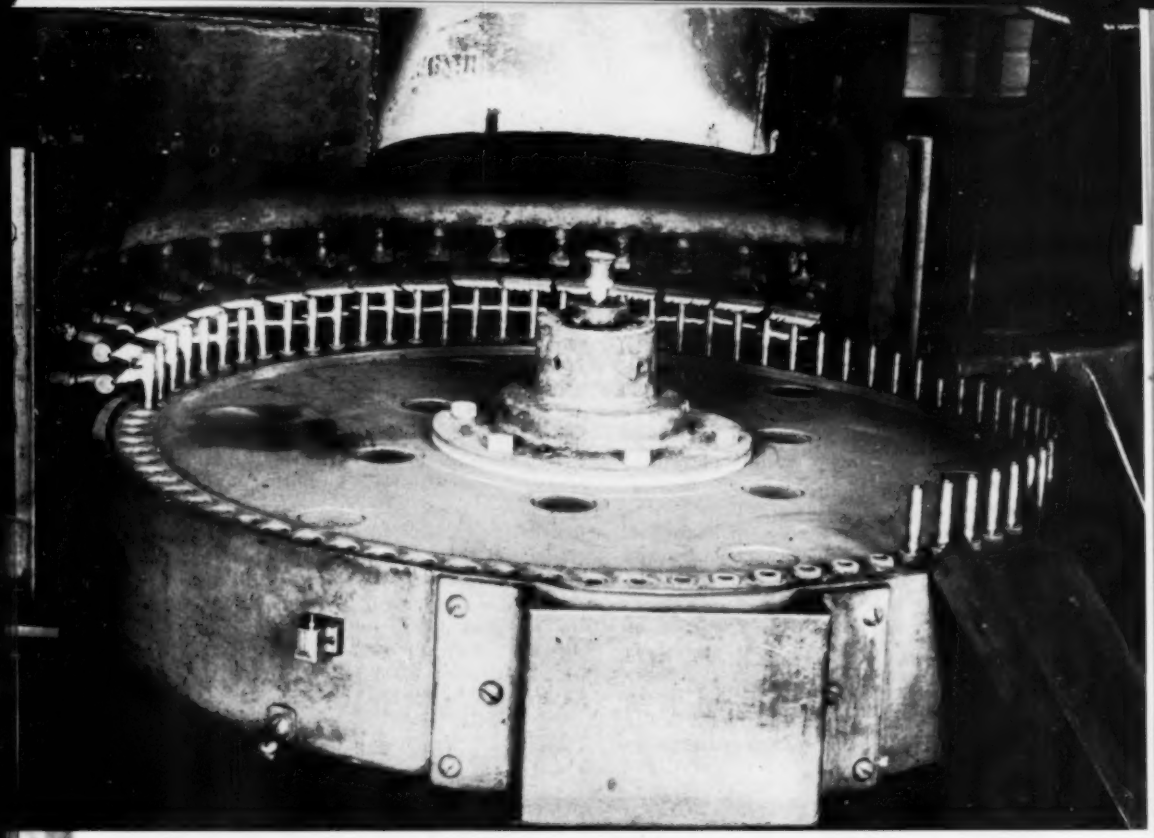


Fig. 4 — The Steel Cartridge Case Program Involved This Experimental Flame Heat Treating Setup for Quench Hardened Caliber .30 Steel Cartridge Cases

ing units or adding instrumentation for metering.

Corrosion — Among the types of treatment studied in the Pitman-Dunn Laboratories are electrodeposited coatings; phosphate treatments for steel, zinc and cadmium; chemical and electrochemical treatments for aluminum and magnesium; pretreatments for organic finishing; metalizing and the waxes for impregnation of metalized coatings; chromate supplemental treatments; fungicidal treatments for various materials; and vapor-phase coating.

The HAE process for coating magnesium was named for the initials of its inventor — a laboratory staff member; its successful use will be described in detail in September *Metal Progress*. This coating protects magnesium so well that it promises wide new applications for this lightweight abundant metal in ordnance and other military equipment.

Measurement of the adhesion of organic finishes to metal surfaces is another project. With the steel artillery cartridge case, shell, or any other ordnance item, pretreatment of the surface and the resulting interfacial conditions are all-important in the performance of the finish.

Extensive laboratory tests have been run under conditions designed to accelerate corrosion, and outdoor exposures have been conducted in nearby industrial atmospheres and in Panama.

Electro-Machining — Research of great importance has been under way for some two years in the Pitman-Dunn Laboratories on the electro-erosive machining of carbides and high speed steels (see article on page 87 of this issue of *Metal Progress*). This technique reduces the need for scarce industrial diamonds and gives fast machining of carbides. A plain steel wheel acting as a rotating cathode can cut through the carbide and steel of a ⅜ x ⅜-in. tool bit serving as anode in a fraction of a minute. A modifi-

cation of this technique uses the side of the wheel as a polishing surface for carbides. Other operations are also possible.

Heat Treatment — A variety of furnaces, quenching tanks, induction heating devices, controlled atmosphere apparatus and sub-zero equipment has been assembled in this division. One special tube furnace has five 6-in. diameter tubes, which may be used with any known furnace atmosphere; electronic controls maintain a temperature to ±2° F. within the range of 100 to 3000° F.

One problem involved the heat treatment of a small zone in the base of a caliber .30 steel cartridge case. To heat treat a pilot lot of 20,000 cases, an automatic apparatus was devised to *(a)* feed a case with its base up into a high-frequency induction coil, *(b)* start a heating cycle of 1 sec., *(c)* stop the heating cycle and quench the case in brine, and *(d)* feed the next case into position, base up.

SPECIAL PROBLEMS

Brass Cartridge Cases — The traditional material for cartridge cases is 70-30 brass, and the traditional method of manufacture has been the cup-and-draw process starting from rolled sheet. Largely because of the lack of sheet rolling mill capacity, new methods investigated have included impact extrusion of slugs cut from cast bar, reverse extrusion of extruded rod cut into slugs, closure of drawn tube ends by spinning, and production of cups by hot forging.

When zinc became scarce, high-copper brasses and bronzes were investigated, such as 90-10 and silicon copper. When the shortages veered to the copper component of the alloy, low-copper alloys were tried, such as 67-33, 65-35 and 60-40. Lower purity materials were also studied, such as remelted cartridge cases, fire-refined copper instead of electrolytic, and even 70-30 brasses containing substantial amounts of impurities derived from scrap.

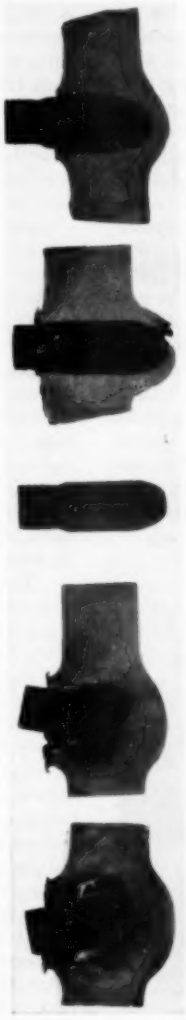


Fig. 5 — Projectile Performance With Increasing Velocity, Top to Bottom. Only the third projectile has penetrated the plate. See "Armor Piercing Shot Program", page 72

A continuing problem has been season cracking, and so much data were accumulated that in 1944 a joint A.I.M.E. – A.S.T.M. symposium on stress-corrosion was held in Philadelphia. The published volume shows that in the section on brass, Frankford Arsenal contributed approximately 75% of the data.

Out of this work came a better understanding of the magnitude and distribution of stress in the cartridge case, and the function of stress-relief heat treatments. The variables in the mercurous nitrate test were carefully studied and related to actual season cracking. An accelerated test using ammonia as the corroding agent was developed as a device to supplement the mercurous nitrate test.

In general, the result of these studies was to improve the quality of our ammunition by discovery of the important process variables and improvement of test procedures. Storage life was increased and the functioning reliability greatly improved.

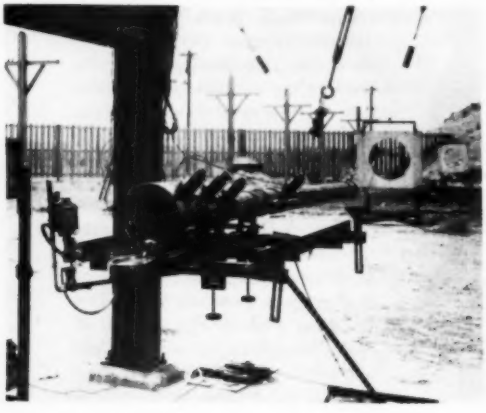
Steel Cartridge Cases — With the beginning of World War II, the critical shortage of copper forced attention to the production of cartridge cases from steel rather than brass. Frankford Arsenal became the center for developing, gathering and disseminating technical information in the steel case program. The services of both the research and the manufacturing units of the Arsenal were utilized, and aid was enlisted from outside research organizations and fabricators experienced in deep drawing of steel. Every phase of case manufacture was studied — selection and preparation of steels, annealing, quench hardening, lubricants, pickling, coating, plating, machining, development

Steel Cartridge Case Research

of material, and related factors such as die angles, die and punch contours, and design of drawpieces. By the end of 1943, this Arsenal and about 57 private companies were manufacturing some 16 distinct types and sizes of steel cartridge cases, ranging from small arms caliber .30 carbine case to the 90-mm. and 105-mm. artillery sizes. Postwar efforts of Frankford Arsenal were directed mainly toward assembling and correlating the large mass of data accumulated in this country and abroad.

The program did not progress to the point where steel cases were judged suitable for direct replacement of brass by the war's end, and the project has recently been reactivated. Under the guidance of the Cartridge Case Committee of the American Ordnance Assoc., plans are going ahead for producing entirely from steel practically all sizes of small arms and artillery cartridge cases. Items in the development for which Frankford Arsenal was primarily responsible include the use of quench hardening treatments to produce the necessary high mechanical properties in the side wall of cases subjected to high pressures during firing (Fig. 4). A method of pretreating cases for coating, together with the phenolic varnish coatings now widely employed, also stems from experiments in which this Arsenal participated. To these may be added the use of phosphating treatments to improve lubrication during drawing, cold extrusion to replace certain drawing operations, and the design and manufacture of new recoilless and multipiece cases.

Fig. 6 — Setup for Testing Recoilless Rifle at the Pitman-Dunn Laboratories



Armor-Piercing Shot Program — The problem of improving armor-piercing shot is a see-saw battle with improvements made in armor plate. To penetrate the target, the shot must possess both high hardness and toughness. This requirement is unique to ordnance but would be a fine combination in industry as well!

Chromium-molybdenum steel WD 4150 was used extensively in the past for armor-piercing, but would not penetrate new armor developed late in the war. From studies of hardenability for deep hardening steel, ductility tests at high hardness levels and ballistic tests, a NE 98V65 (modified) steel was designed; isothermal transformation studies were conducted and its S-curve was constructed. This steel is currently in use. To correlate ballistic behavior with composition, and to determine if a particular alloying element confers any superior properties to the projectile, the ballistic performance of special steel compositions was systematically studied on reduced scale models.

One of the most difficult problems in the manufacture of projectiles lies in heat treating techniques. Since the shot must be extremely hard — in the neighborhood of Rockwell C-60 — rapid quenches are necessary. Conventional quenching in brine, water, or oil usually results in serious cracking. In 1945 a first attempt was made to apply the martempering process to the hardening of armor-piercing shot, with successful results.

To further complicate the various metallurgical phases of the problem, there is the ever-present complexity of shot geometry. Since variations in the design and shape of the shot in turn affect the control of the other variables, the solution is obviously a difficult one. Figure 5 illustrates a unique behavior of projectiles upon impact. The increase of striking velocity increases penetration up to a certain velocity, above which the projectile shatters against the plate without penetration.

The three special problems described above are but representative of others which confront the Pitman-Dunn Laboratories at Frankford Arsenal. However, they illustrate the degree to which metallurgical effort must be brought to bear upon ordnance problems vital to the defense of our country.

Westinghouse Electric Correlates Its Product Development With Research

By John Parina, Jr., Associate Editor, Metal Progress

TO DESCRIBE the past and present activities of the metallurgists at Westinghouse within the limits of a short article is a difficult task, for in a period of some 30 years a research organization as aggressive as that of Westinghouse accumulates many metallurgical discoveries and much knowledge. One must be content, therefore, in following only the general sweep of its progress.

A visitor making the rounds of the Westinghouse research and development facilities at East Pittsburgh is struck by the diversity of activities, the close coordination between production and research, and the lusty vitality of the research effort. With a relatively small research staff (at present of about 500, 30 are in metallurgy and magnetics) and a modest physical plant, Westinghouse has, nevertheless, kept abreast with the challenging variety of metallurgical problems associated with the firm's 8000 diverse products.

Research and development at Westinghouse is done by two groups; the first is at the Research Laboratories and devotes itself to the fundamental task of learning what factors control the properties of metals, and from this knowledge creates alloys for specific applications. The second group, the Materials Engineering Department, has as its task the development of production processes and the necessary quality control measures. This to some extent explains the close coordination between production and research: Many phases of manufacture are conducted on a pilot-plant basis which, out of economic necessity, are continually subject to improvement.

That the metallurgist's task is not an easy one can be interpreted from such statistics as 2000 different metals and combinations of metals being used in the company's products, these including some 420,000 tons of rolled steel products in 1951, and that virtually every fabricating and finishing process found in widespread industry is involved to some extent. Although most of the metallic tonnage used is the usual commercial grades of aluminum, copper, and steel, a great many special alloys are made in the pilot operations. These, incidentally, run into sizable production in a year. Alloys sold under the trade names "Hipersil", "Hipernik" and "Hiperco" are examples of such special alloy products for electrical equipment.

"Hipersil" alloy, the first of this family of high-permeability metals, was born in the early 1930's and developed to a commercial state just prior to World War II. Credit for its development is shared jointly by Westinghouse and Armco Steel Corp., the present manufacturer. Their talents were combined in producing an iron-silicon alloy possessing a large proportion of preferentially oriented grains. Much of the fundamental work of finding the cycle of thermal and mechanical operations which influence the favorable alignment of the individual grains in the normal polycrystalline material was done by the late T. D. Yensen and his associates of Westinghouse.

One of the tough problems that had to be solved to obtain a metal having highest magnetic permeability and lowest core losses was the removal of virtually all of the impurities then found in the commercially pure alloys of this type. This involved the included oxides and silicates, as well as certain types of iron oxide on the surface which had a deleterious effect on the material during subsequent processing. Carbon is also in the class of undesirables — its upper permissible limit being in the neighborhood of 0.01%. There was the question of furnace atmospheres during the annealing cycles and the associated problem of what constituted an acceptable surface scale, both as to its influence on electrical properties and its effect on die life. Also, in an oriented material the magnetic flux must be passed through the material in the same direction the grains are oriented, but to control magnetic flux

Important Magnetic Alloys

direction it was necessary to design a special core shape. It is obvious that all of this adds up to a lot of work. Westinghouse now uses the material in practically all of its transformers, and these range from ½-oz. units for radar equipment to 250-ton giants on power transmission networks. They weigh as much as 40% less than those constructed from conventional magnetic alloys, have a greater short-time overload capacity, and a lower impedance.

Another example of alloy discovered at the Research Laboratory and carried into production by the Materials Engineering Department is "Hipernik" alloy. "Hipernik" is a relatively high-saturation alloy of 50% iron and 50% nickel. Its saturation induction is 16,000 gausses, which places it in a different class from a number of other commercially available nickel-iron alloys, and it is especially suited for special transformer cores where very high permeability is desired. It is finding considerable use in the field of magnetic amplifiers where there is also wide application of a sister alloy, "Hipernik V", which was created by the Materials Engineering Department. The latter alloy is characterized by a rectangular hysteresis loop and a very high ratio of residual induction to induction at saturation. This core material has made it possible to devise magnetic amplifiers with single-stage power amplification of over a million to one, and should lead to a new era in industrial control mechanisms.

Certain iron-cobalt alloys have desirable magnetic properties but are unusually difficult to fabricate due to excessive brittleness, even in the annealed condition. "Hiperco" alloy, which contains approximately one-third cobalt, two-thirds iron, and of the order of 1% of one or more metallic elements to increase the electrical resistivity, has a permeability at high inductions about 20% greater than the purest commercial iron and 30% higher than 1% silicon-iron. Here again the correct rolling and annealing cycle had to be found, but this time to impart ductility for processing operations, as well as magnetic properties.

In contrast with these processing difficulties, "Kovar" (29% Ni, 17% Co and 0.3% Mn, balance iron) is a readily formed alloy. Its low expansion (mean expansivity for a range of 25 to 400° C. is 0.0000045) affords a match with hard glasses. Sealed to hard glass, the joint has excellent resistance to thermal shock and withstands the high temperatures necessary for fast degassing of vacuum tubes. The sound metallurgical engineering underlying this development is indicated by the fact that efforts during the past 15 years to replace or supplant this special alloy have not succeeded.

Westinghouse has played a unique part in the promotion of many of the so-called rare metals including thorium, zirconium, tungsten, uranium, molybdenum, and vana-

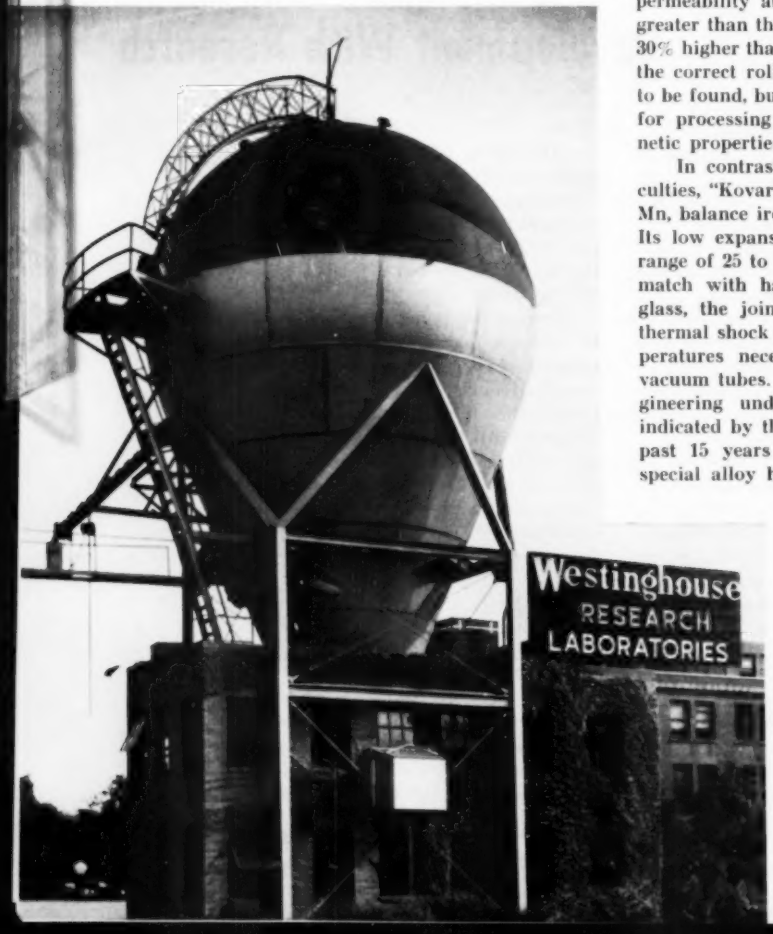


Fig. 1 — Structure Housing the Van de Graaf Electrostatic Generator on the Research Laboratory Grounds Symbolizes Modern Transmutation of Metals

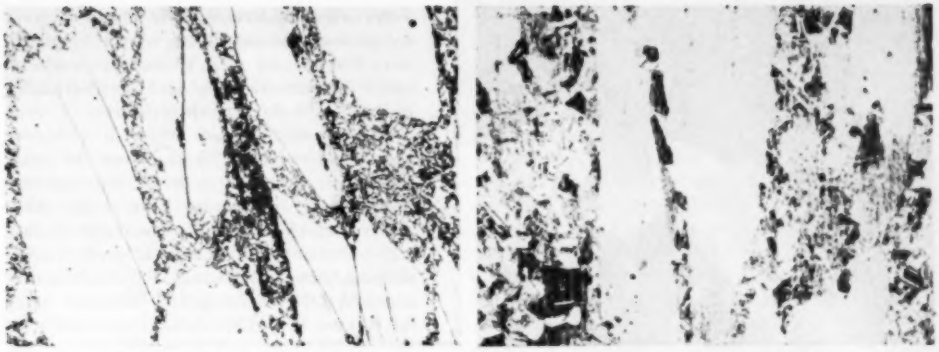


Fig. 2 (Left) — Nonuniform Structure in "K42B" Resulting From Conventional Hot Rolling of Coarse-Grained Billet; 100 ×. Fig. 3 (Right) — After Solution Treatment, Recrystallization of Structure Shown in Fig. 2 Is Only 50% Complete; 100 ×

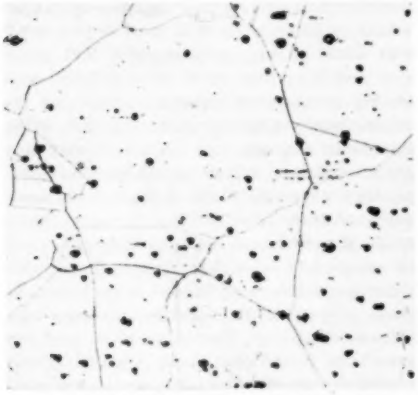
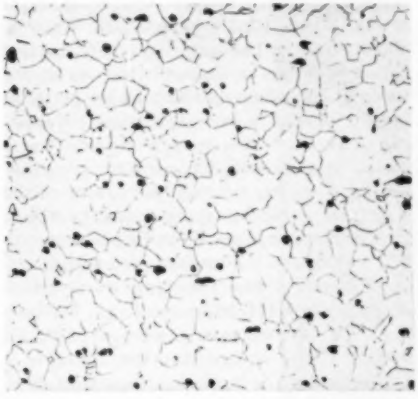


Fig. 4 — Initial Coarse Grained Structure of "Discaloy" Before Hot Working. 100 ×

Fig. 5 — Small Equiaxed Grains Resulting From Three Cycles of Controlled Hot Working and Reheating Applied to the Structure in Fig. 4. 100 ×



dium. Much of this work has been carried out in the Lamp Division of the company at Bloomfield, New Jersey. The beginning of this story goes back to the early 1920's when both molybdenum and tungsten were being produced in commercial quantities by the company.

The use of tungsten as a lamp filament is well known, and molybdenum plays an important role as a material for leads, supports, and also mandrels around which tungsten may be coiled. In this latter application, the metal for the mandrel had to have a high melting point to withstand the temperatures required for setting the tungsten coils, and, chemically, it had to differ from tungsten so that the mandrel could be dissolved away from the tungsten coils.

WORK ON HIGH-TEMPERATURE ALLOYS

With the start of World War II, the work on high melting point metals and alloys received a powerful impetus because of the demand for serviceable materials in jet engines and gas turbines. Molybdenum and molybdenum-base alloys, because of their high strength and low creep at elevated temperatures, became particularly fertile fields of investigation.

The company has played an important part in this expansion by discovering new treating methods for the production of massive pieces of pure molybdenum weighing 250 lb. and more.

In World War II, Westinghouse made an exceedingly important contribution to the field of atomic energy by supplying most of the pure uranium for the first atomic pile at the University of Chicago.

Fig. 6 — Wax Pattern of a Cluster of Turbojet Blades After Dip Coating and Dusting With Fine Sand

Following the war, the company expanded its activities in the fields of nuclear energy, and the success of these adventures is critically dependent upon the development of many new alloys and metals. The challenge is being met by combining a theoretical and practical approach.

"Konal" (one example being 72% Ni, 17% Co, 2.2% Ti, balance Fe plus deoxidizers), one of the earliest of Westinghouse superalloys, came into being as a result of the search for a replacement for platinum in radio tube filaments. Its hot strength led to the speculation that it could be used as a high-temperature alloy in air, and by adding chromium and making other modifications in its composition the alloy "K42B" was created. Immediate use awaited it in blades which operated at 1450° F. in the Wright aircraft engine supercharger. However, one difficulty stood in the way of its immediate widespread acceptance. Because of its high titanium and the fact that the available ferrotitanium contained high aluminum, the K42B had many nonmetallic inclusions. When purer raw materials were used, cleaner ingots were obtained from which the blades were forged and cold formed successfully. Later the material was used for the blades in the Westinghouse 19B turbojet.

Other alloys that followed were the titanium-hardened "Refractaloy 26" and "Discaloy" and the molybdenum-hardened Refractaloys 70 and 80. The Refractaloy alloys are nickel-cobalt base materials having high-temperature strength and oxidation resistance between 1300 and 1500° F. Discaloy is a precipitation hardening iron-base alloy for service up to 1200° F. in rotors and bolts for gas turbines, and in modified form for structural parts of electrical apparatus where nonmagnetic characteristics are needed.

According to Howard Scott, manager, metallurgical and ceramic department, under whose guidance since 1940 most of this work was done, it was early realized that grain size and structure must be carefully controlled in titanium-hardened alloys for reproducibility of mechanical properties. High endurance strength was associated with fine grain, especially when the alloys were completely recrystallized. Controlled work hardening of these alloys — that is, appreciably below the minimum limits of hot working — is essential for complete recrystallization to a fine grain size, and this led to a systematic study of recrystallization and grain growth. (More about this shortly.) Scott and his associates found that work hardening was practically as effective at elevated temperatures as at room temperature, *so long as recrystallization did not occur during working*. This so-called "hot cold-work" was a drastic departure from the accepted techniques of that time.

Coming back to the study of recrystallization and grain growth, F. C. Hull, manager of the metallurgical section of the Westinghouse Research Laboratories, has found that optimum grain refinement for most hot forming operations is obtained by performing the operation in several steps. Reheating after each deformation is only for a period long enough for complete recrystallization. Shorter holding times cause mixed structures similar to those shown in Fig. 3. Longer holding times result in grain growth and a return to the original structure.

Figure 2 shows a nonuniform structure produced in K42B by conventional hot rolling. The rolling was started at 2100° F., with a 1¾-in. square that was rolled to a 1¼-in. round — a reduction of area of 60%.

About 20% recrystallization occurred at the original coarse grain boundaries during rolling. Such mixed grain structures do not respond readily to heat treatments. When solution treated 1 hr. at 1750° F., recrystallization is only 50% complete, Fig. 3. Remnants of the elongated original grains are still present. If the solution temperature were raised high enough to get complete recrystallization, the whole bar would become coarse-grained.

A starting condition for wrought Discaloy is shown in Fig. 4, the A.S.T.M. grain size No. 1 to 2 being established by a ½-hr. soak at 2200° F. Figure 5 is the grain refinement resulting from three cycles of working and controlled reheating at 2200° F. An A.S.T.M. grain size No. 6 was produced with only 50% total reduction of area.

INVESTMENT CASTINGS

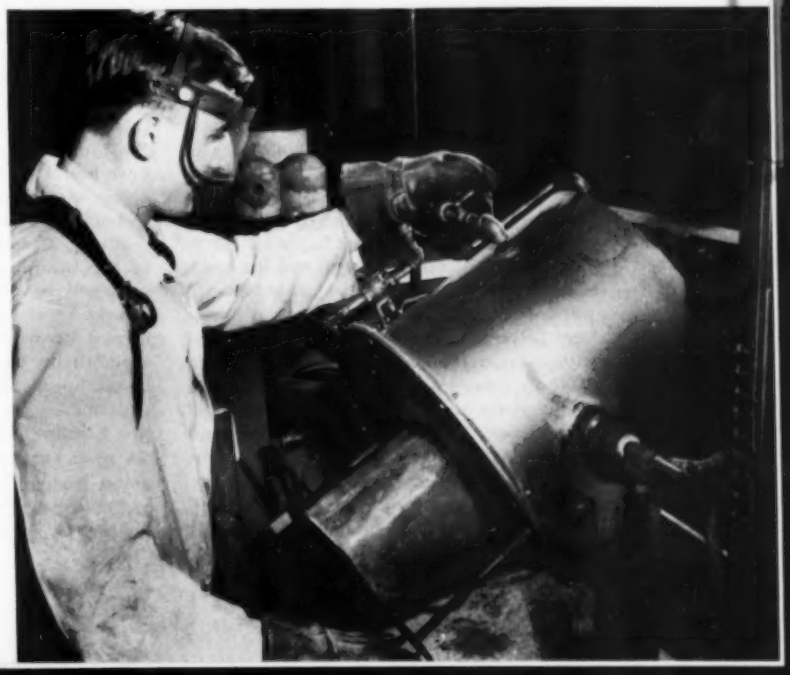
Improvements in investment casting were as important to the expanded uses of high-temperature alloys as was the "hot cold-working" technique. Investment casting processes in use at Westinghouse today not only assure closer tolerances than obtained ten years ago, but are also by comparison mass production methods. For example, the dry investment, consisting of refractory sand and an organic silicate (which on hydrolysis yields a silica in colloidal form) is blended in a 300-cu.ft. double-cone blender in quantities sufficient for a week's supply, this being held until time for use in storage tanks. An 8-cu.ft. blender was adequate when the method was first used for turbo blades. At that time, too, the blades were cast singly; at the present they are made in clusters of half-dozen or more (Fig. 6). Another improvement in technique was to subject the wet investment to vacuum, thus packing it densely about the mold.

At the present time, a dozen alloy compositions of the high-temperature oxidation-resistance type are being used; castings range in weight from a fraction of an ounce to over a pound. Melting stock for the 10-lb. arc furnaces used in the precision casting department is made in 600-lb. induction furnaces and shotted. Shot from six heats are blended to obtain greater uniformity of composition. (Incidentally, the carbon content in many of these refractory alloys is controlled within 0.02%.)

Approximately 50% of the cost of turbo-jet blades lies in their finishing and inspection. Improvements in casting techniques, coupled with modification of standards made possible through field experience, should permit substantial improvement in this percentage in the future. However, because of the extreme service requirements, a 100% inspection is required for internal soundness (X-ray) and surface integrity ("Zyglo").

"Shell molding" is also under investigation; 100 to 200-lb. castings of aluminum, iron, bronze and stainless steel have been made. Here again close dimensional tolerances are the objective, as well as good surface condition and internal soundness. Tolerances being obtained at present are of the order of 0.002 to 0.003 in. per inch of length — half that of best conventional methods.

Fig. 7 — A Small Arc Furnace Used for Investment Casting at Time of Pour. Mold is clamped on the furnace mouth before it is tilted about 145° to position shown



What Makes Metal Strong?

In another department, gases in metals and their effect on product quality are being studied. Hydrogen, for example, is known to be detrimental to the ductility of many metals. Hydrogen has also created a problem by causing blisters on thick steel plate having babbitted surfaces. This appears to result from diffusion of the hydrogen from the steel to the steel-babbitt interface. Investigations of the effect of hydrogen content on its diffusion rate at various temperatures and the critical hydrogen value for blistering are under way.

Another subject currently being investigated is the notched-bar strength at elevated temperatures for the different metals used in jet engines and gas turbines. Service life of rotors, couplings and bolts is directly related to notch sensitivity, high stress concentration being caused by slots, bolt holes and the discontinuities at the heads and the sharp threads. A recent investigation conducted by Hull, Hann, and Scott evaluates the relationship between notch sensitivity and ductility (creep-rupture) as affected by the hardening agent, titanium, at 1000 and 1200° F. It was found that the titanium content had to be controlled very closely to obtain the best combination, and that the notched-bar strength diminishes at an increasing rate as hardness is increased above a maximum of approximately Vickers 290.

Another research project that has been completed recently is the investigation by Scott and Olleman of the effect of hardness on the strength in torsional and in plain and notched-bar tension loading. Toolsteels were studied, and it was found that maximum fracture strength occurs at the highest hardness for torsional loading, next highest for tension and bending, and at the lowest hardness for notched-bar tension (bars with an elastic stress concentration factor of 3.2 to 3.9). Both maximum strength and the hardness at which it was obtained were lowered when either grain size or retained austenite were increased. Fracture surfaces obtained with torsion tests confirm the observation made by other investigators that fracture in metals starts either on planes of maximum sheer stress, or planes of maximum normal stress. That, and a number of related observations on high-temperature alloys, leads to the conclusion that grain boundary strength is a major factor determining strength and ductility at elevated temperatures as well as at normal temperatures.

Although it is known that grain-boundary fracture strength can be increased by grain refinement, by substitution of cobalt for iron plus nickel, and by the addition of molybdenum up to the limits of solid solubility, this basic property of metals demands additional study.

So much for the past and present, but what of the future?

Howard Scott asks some pertinent questions, and these may be a clue of the direction in which his researchers might embark. Some of his questions are: Why do metals change from brittle to ductile behavior? Why do metals work harden? How can yield strength be increased without reducing ductility? How can fracture phenomena be used to interpret test results?

The most pressing need facing not only metallurgists but also designers and fabricators is for knowledge of strength of metals and their alloys.

This may seem like a lot of esoteric stuff to those interested in so-called short-range or "paying" research (although a good argument in favor of the latter could be made from Westinghouse's own past successes). Just to keep the record straight, Westinghouse is not ignoring practical research. Work is progressing on a device to control the true carbon potential of prepared atmospheres; on a furnace for continuous nichrome "brazing" of material such as Stellite at 2100° F. in dry hydrogen; on the effects of current wave shape on quality of resistance welds; and on true action of the arc in arc welding.

However, there is much evidence that the thoughts pertaining to future research have been cast from a new mold. New and better alloys are needed, not only because of technological necessity but also for economic reasons. The problem of finding new alloys in the future, says J. A. Hutcheson, vice-president in charge of research, must be based on a scientific approach, using fundamental knowledge to predict exactly what kind of alloy will be formed from the known quantities of the constituent metals. The days of adding a pinch of this and that metal to a handful of another and then waiting to see what happens are coming to a close; as alloys become more complex, neither time nor money will be available for such costly "cook-book metallurgy".

Protecting Metal Surfaces With Paint

By Allen G. Gray, Consulting Editor to Metal Progress

THE SUCCESS or failure of a protective paint system may depend largely on the proper selection of the surface condition to which it is applied. The theory of adherence and bonding, and the practical application of the principles involved, go hand-in-hand. It is generally agreed that two major factors determine the bond between paint and metal: One is molecular attraction between the coating material and the metal surface; the other is the keying of paint to metal, termed mechanical bonding. In most paint coatings both forces are present in varying degrees.

Blast Cleaning — In the Third Interim Report of the Surface Preparation Committee TP-6G of the National Association of Corrosion Engineers (N.A.C.E.), A. J. Liebman of Dravo Corp. describes a number of surface conditioning procedures for protective coatings. According to Mr. Liebman, the average paint manufacturer will specify or prefer a blast-cleaned or chemically etched surface free of mill scale. However, there are times when economics may dictate against a surface where all mill scale is completely removed. If the product does not have to operate under severe operational stresses nor surface impacts and excessive vibrations, the paint may be applied after all rust and loose scale products have been removed by a brush-off sand-blasting that does not remove tight mill scale. Here, the selection of a primer or coating with proper surface wetting and adhesion characteristics becomes important, since little or no surface cavity "anchor" is available. Such surfaces have been found suitable for either an adhesive or bonding-type coating.

However, if impact and other surface forces will produce undue stresses, or if the coating serves in a marine environment, nothing less than a thoroughly blasted surface should be considered. The N.A.C.E. Surface Preparation Committee has classified such blasted surfaces into two groups. Condition No. 1, known as the "white steel" surface finish, covers the complete removal of all corrosion products, all mill scale, and the gray mill scale binder, thus exposing the underlying metal for the best mechanical connection for all coatings. Under favorable conditions, on new flat steel, single nozzle sand-blasting can clean from 75 to 140 sq.ft. per nozzle hr. with a $\frac{5}{16}$-in. nozzle at 100-lb. nozzle pressure. The suggested nozzle distance from the steel surface is 12 to 18 in.

Condition No. 2, designated as a commercial surface finish, includes the complete removal of all corrosion products, as well as all tight and loose mill scale. It does not include the removal of the gray mill scale binder. A commercial blasting job will look rather streaky; however, it does produce a good surface anchor for all coatings. Under favorable conditions, on new flat steel, sand-blasting of this type can clean from 240 to 450 sq.ft. per nozzle hr. for $\frac{5}{16}$-in. nozzle and 100-lb. pressure. Nozzle distance from steel is generally 18 to 24 in.

For optimum mechanical bonding of paint coatings, the depth of blasting etch should be limited to one third of the total thickness of the entire coating system. A sand-blast pattern should be uniform for best results. Nonuniform and impure blasting sand produces cavities on the surface which, on atmospheric exposure, will trap chemical products. Also, the edges of the cavities generally receive less paint than does the more uniform surface. In underwater exposure, greater wear and an earlier coating breakdown at the cavities may result from turbulence. Figure 1 shows a non-uniform sand-blast pattern at left; a uniform pattern above. Sand that is to be re-used must be dry and should be screened to original sizing.

Grit and Shot-Blasting — Grit or shot of specific grain size discharged at a velocity to give sufficient impact will remove mill scale and corrosion products. Various types of abrasives are now available, including *(a)* chilled iron shot and grit; *(b)* malleable iron shot and grit; *(c)* copper shot; *(d)* high-carbon steel shot; and *(e)* certain non-metallic abrasives. According to the N.A.C.E. Corrosion Committee report, copper and high-

carbon steel, in general, give the lowest operating costs due to long abrasive life and slight wear on machine parts. The surface roughness produced is dependent upon the shape, hardness, velocity of the abrasive medium, blast exposure time, and the physical properties of the metal being blasted. Here again the depth of blasting is held to about one third of the total thickness of the entire coating system.

Wire Brushing will remove all accessible loose scale and other loose corrosion products, but will not remove tight oxide and mill scale or any embedded corrosion products. Wire-brushed and scale-covered steel does not constitute an acceptable surface anchor for all protective coatings. A coating with good adhesive and wetting characteristics should be used. Excessive power wire-brushing sometimes results in an undesirable burnished condition of the metal surface.

Flame Conditioning—This method employs a hot brushlike flame that is rapidly passed over the metal to be descaled. The heat causes the loose and some of the tight mill scale to spall. Most corrosion products are similarly affected. The method also has the advantage that the local heat reduces the moisture film on the metal surface. To take full advantage of this method, a coat of primer or protective coating should be applied on the surface before any new moisture can form. Sometimes it may be necessary to wire-brush the surface immediately after flame conditioning to remove partially loose or upturned scale.

Chemical Methods—Surface cleaning processes with solvents, alkalis, and emulsions for the purpose of removing all contaminants, grease and oil, do not react with the metal and it should be painted immediately, or followed by either the surface reaction or surface conversion treatment. Surface reaction with dilute acids slightly etches the metal. Paint should be applied after the metal so treated has dried and before deleterious products can deposit or form. Surface conversion treatment generally involves the forming of a compound of the metal on its surface which is less corrodible than the metal itself. Vinyl metal conditioners are applied to inhibit the metal, give temporary protection against corrosion, en-

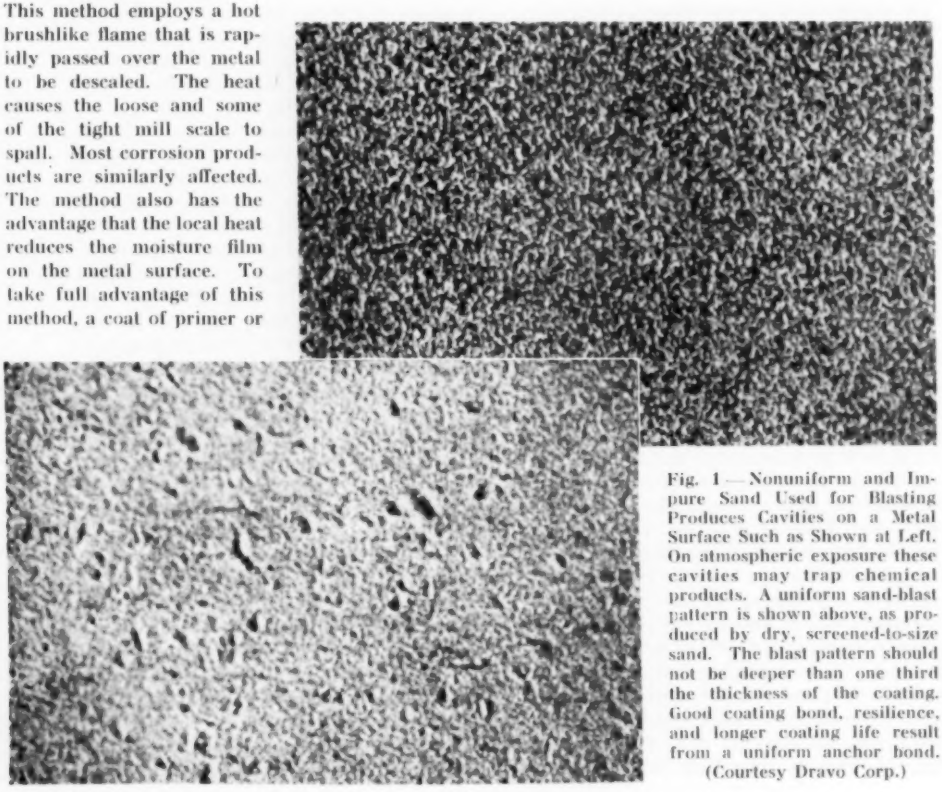


Fig. 1—Nonuniform and Impure Sand Used for Blasting Produces Cavities on a Metal Surface Such as Shown at Left. On atmospheric exposure these cavities may trap chemical products. A uniform sand-blast pattern is shown above, as produced by dry, screened-to-size sand. The blast pattern should not be deeper than one third the thickness of the coating. Good coating bond, resilience, and longer coating life result from a uniform anchor bond. (Courtesy Dravo Corp.)

hance adhesion of subsequent coatings to metal, and retard corrosion.

Inspection Before Coating — Obviously, dust, sand and other contaminants should be removed from the surface before a prime or first coat is applied. The wetting strength of paint can be weakened by a surface that was apparently well sand-blasted but carelessly inspected before the paint was applied. When this happens, the accumulation of sand and corrosion dust on the surface prevents proper surface wetting and adhesion of the primer coating. Such dust will act like the surface itself and attract a considerable percentage of the first coat's wetting strength. What may be left is insufficient to wet the much-increased area of the blasted surface and a poor surface bond and early paint failure can result.

Fig. 2 — Protective Coating of Paint Being Sprayed on Liberty Ship Life Raft. (Courtesy DeVilbiss Co.)

Because corrosion is an electrochemical process involving interaction between a metal surface and its environment, it can be prevented by the interposition of a film between the metal surface and its environment that is impermeable to the corrosive factors of the environment. At the meeting pertaining to the protection of submerged surfaces, which was a part of the Third Symposium on Paint and Varnish Chemistry sponsored by New York University, A. C. Elm of New Jersey Zinc Co. pointed out that the degree of this desired barrier effect achieved in a protective coating is a function of the continuous phase of the coating, that is, the matrix or vehicle. To utilize fully the inherent capabilities of a vehicle, the detailed mechanism by which various corrosive agents permeate or penetrate it should be understood.

THEORY OF PAINT PROTECTION

It has been established that even a perfectly continuous and pore-free film is not impermeable. Permeation of moisture through films is by a mechanism similar to solution; the water molecules dissolve in the film substance by attaching themselves to the polar groups, which are a part of the molecules making up the film substance, until all, or nearly all, of the groups are hydrated. It is believed that osmosis is a factor in this mechanism.

The nature and concentration of these hydratable groups may determine the rate of water absorption by and diffusion through the film. Among the polar groups which can serve as hydration centers are OH^-, OOH^-. Such groups usually are present in film matrices formed by oxygen-induced polymerization. Examples of such film formers are the drying oils and their modifications. Films which are formed by reactions not involving oxygen are generally more impermeable to moisture than films formed as a result of auto-oxidation. That is one of the reasons why baked films usually possess greater moisture resistance than air-dried films, and why vinyl films have such outstanding water resistance. Pigment particles, in general, can increase the resistance of a matrix to penetration by water vapor merely by forcing the water molecules to detour around them.

Effect of Electropotential Gradients — In actual practice, the situation is not quite so simple. Since corrosion is an electrochemical process, the electrical potential gradients set up across a paint film deter the transport of water through the film. The quantity of water that can be transported under the influence of ordinary corrosion currents has been found to be many times that which is pushed through the film by osmotic forces. As a result, the anti-corrosion properties of a coating become more important than its water resistance in

(Continued on p. 142)

By A. L. Boegehold, Assistant to General Manager, Research Laboratories Division
General Motors Corp., Detroit

Proof Testing of Full Sized Automobile Components*

It is now at least 175 years since the strength of iron used for buildings and bridges has been studied. Testing machines at Woolwich dockyard, in England, provided much of the data needed for engineering design 125 years ago. In this country the classic tests on materials published in the annual reports of Watertown Arsenal since 1880 remind us that ordnance was in advance of civilian manufacture in this respect.

It would require an extended historical research to fix the growth, step by step, of the idea that the figure representing strength of materials depends upon the size and shape of the test piece, the way it is loaded, and the speed of loading. Suffice it to say that the present day finds us with many accepted standards in this field, yet there is no end of special equipment newly designed to load simple test pieces in new ways, at extremes of temperature and under various environments, and to record accurately the response of the metal.

The work of testing engineers has rightly stressed the use of standardized procedures, since only in that way could results be reproducible, and any agreement reached between purchaser and vendor when material was bought to strength specifications. Likewise, there is no question but that the simple tension test will enable the engineer to discriminate between good and bad steel. However, it is one thing to translate the figures for strength, yield, and elongation into safe performance in a bridge eye-bar, and quite another into safe performance of a heat treated steering knuckle. One thing is sure, and that is that the situation is very complicated when the designer and metal engineer try to translate laboratory results on simple test pieces into safe design figures for machine parts operating under dynamic loading.

Although engineers haven't realized the complexity of this situation over the years, they have known that the only way they could get an answer in usable terms was by making a simulated service test, or by a stroking test on the particular component that they were interested in developing, wherein the part was exposed to a definite number of deflections of controlled amount. For such purposes they have developed much specialized testing apparatus. It was about 15 years ago when I first realized that we couldn't predict from laboratory tests on standard test pieces what kind of results we were going to get on a stroking or fatigue test conducted on the components themselves. This point was made clear in the testing of rear axle ring gears.

We made numerous laboratory fatigue tests on specimens made of different steels, heat treated in various ways. Then the same steels and treatments were applied to rear axle ring gears and assembled in a complete rear axle. This was then tested for fatigue in a machine shown in Fig. 1. The propeller shaft is driven by a dynamometer motor, and at the ends of the axle, instead of the wheels, are electric generators in which the field strength is variable. Thus the load on the rear axle is controlled.

This rear axle test is run at low gear torque. Table I shows results on ring gears made of different steels and treatments (as determined by this rear axle dynamometer) compared with results for these same steels run as small standard test specimens in a rotating beam fatigue machine.

The steel used in these Chevrolet rear axle ring gears at the time was 2315, a 3.5% nickel carburizing steel. The first column shows the different steels studied in this investigation, the second column shows the case depth, the next column shows the heat

*This article is a portion of a talk presented to the Rochester Chapter, American Society for Metals, in March 1951, to the General Motors Metallurgical Committee in February 1951, and to a meeting of the department heads of the General Motors Research Laboratories that same month. The second portion of the talk, covering "Selection of Steel for Automobile Parts", will be published in the September issue.

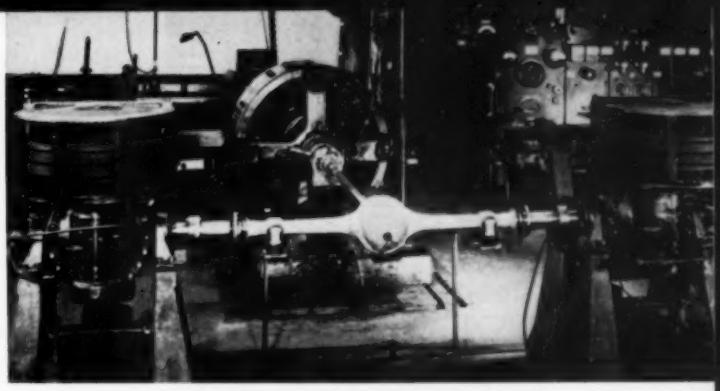


Fig. 1 — Early General Motors Testing Machine for Determining Endurance Limits of Rear Axle Components. Propeller shaft is motor driven; power is taken off by electric generators at each end of axle

treatment, the next two columns show results of laboratory tests on standard small samples heat treated identically with the gears, and the last column shows the number of cycles until failure of one of the teeth on the rear axle ring gear.

According to data from the dynamometer (Fig. 1) the standard ring gear tap line was the best of all steels tested, but in the laboratory fatigue tests on the plain specimens, the standard material and heat treatment showed about the shortest life of any. Also, the specimen with a notch (to simulate the notch concentration on rear axle ring gears), given the standard steel treatment, showed the lowest life except one. A 3.5% nickel steel with 0.30% carbon (2330), provided with a shallow case, showed an extremely high endurance limit in the R. R. Moore machine, represented by a life of 20 million cycles when tested at a stress range of ±120,000 psi., and the notched specimen had the longest life of any. At first we thought we had a wonderful new material and treatment for rear axle ring gears, but it didn't pan out that way in the ring gear test!

There are at least four reasons why the ring gear tests do not agree with the tests on small specimens. One is the difference between the structure of the ring gear and the small specimen at the place where failure occurs. Second, because the quenching rate in the gear isn't the same as at the surface of the little laboratory specimen, the residual stress pattern is quite different. Third, the stress concentration resulting from the externally applied load is different at the base of the ring gear teeth. Fourth, and probably most important, the tooth contact pattern is not as good in the ring gears made of the experimental steels as it is in the ring gears taken from production. The method of generating the ring gear teeth for the production gear had been determined by many experiments over a long period of time, gradually approaching a good tooth contact, resulting in uniform load distribution and long life.

Now if we had been able to make sufficient experiments with the experimental steels in ring gears to determine the correct cutting of the teeth so as to get the best pattern of tooth contact, we would have seen an entirely different picture in the rear axle tests. Actually, in later work it was possible to obtain a greater life with 1.75% Ni, 0.25% Mo, 4615 steel than with the 2315 steel. This was done

Table I — Tests on Steels and on Gears Made Therefrom

Steel	Case Depth, In.	Heat Treatment*	Cycles to Failure in R. R. Moore Machine		Cycles to Failure as Gears
			Plain Specimens at 120,000 Psi.	Notched Specimens at 50,000 Psi.	
2315	0.042 to 0.053	A	160,000	250,000	812,628
2315	0.047 to 0.053	B	900,000	500,000	286,181
2315	0.053	C	—	—	486,802
2315	0.047	D	3,000,000	—	403,782
2330	0.030	E	20,000,000	1,200,000	323,925
Mn-Mo	0.060	A	—	200,000	268,426
1315	0.067	A	—	500,000	302,863

*A: Direct quench in oil; reheat to 1330° F., oil quench; temper at 300° F.
B: Direct quench in oil; temper at 300° F.
C: Transfer from carburizing heat to furnace at 1375° F.; quench in oil; temper at 300° F.
D: Direct quench in oil, reheat to 1475° F. in cyanide, oil quench; temper at 300° F.
E: Direct quench in oil; reheat to 1375° F., oil quench; temper at 300° F.

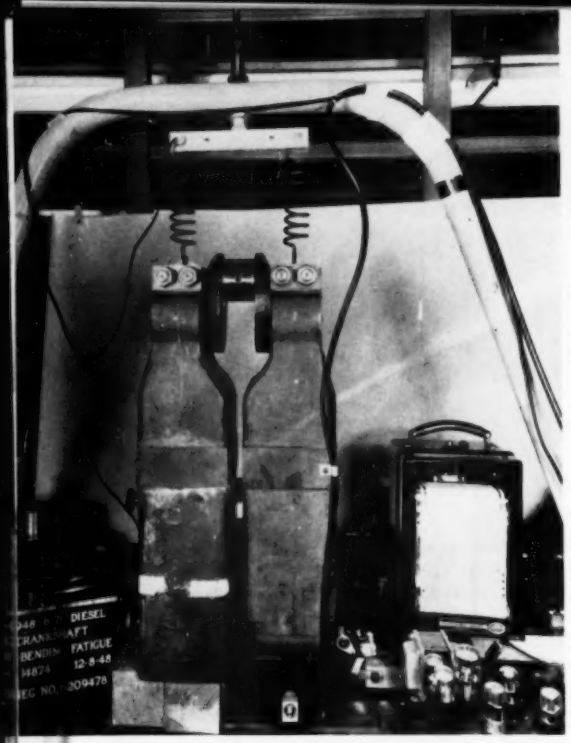


Fig. 2 — Machine Developed by Van Degrift for Testing Single-Throw Crankshaft. Small motor hung under right weight has unbalanced rotor, and it sets up resonant vibration in the system

by manipulating the generation of the ring gear teeth until as good a tooth contact as that of the old production gears was obtained.

This illustrates the value of these special fatigue testing devices for automobile components. Another special apparatus for testing steels in crankshafts is shown in Fig. 2.

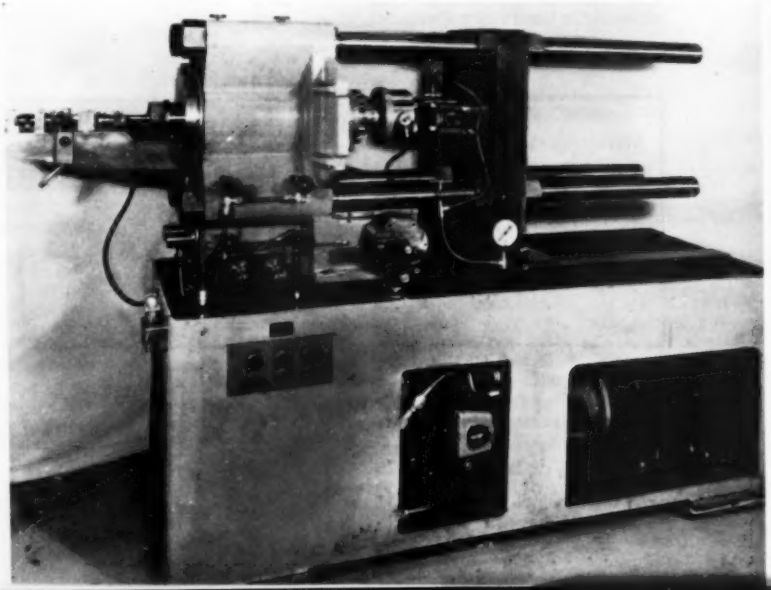
This apparatus was developed in General Motors Research Laboratories by T. C. Van Degrift and his associates, and it was much used in the last war for testing the materials for the Allison aircraft engine crankshaft. The test is conducted only on a section of the crankshaft shown at the left of the machine above the placard, which included two main bearings, one crank throw and the crankpin. Heavy weights are clamped to the two main bearing journals. On one of these weights is hung a small motor with an eccentric weight on the armature shaft; as it rotates it causes the weight to vibrate. The motion is transmitted through the crankshaft to the other weight, so that a resonant vibration is set up at the natural frequency of the whole system. The stress in the crankshaft is controlled by a contactor in an electronic circuit which regulates the amplitude of vibration as a function of exciter motor speed.

With this type of test a good deal of valuable information has been obtained not only on materials, but also on the design of crankshafts.

Available also are a number of different general-purpose testing machines for testing automobile components. One on the market is the Sonntag fatigue tester. The top of the machine at bench height is the worktable where the component to be tested is mounted. The desired deflection is imposed by means of motion originating in a reciprocating weight below the table. The motion is imparted to a spring, which in turn is connected by rods to the specimen above the table. This is a constant-load machine, as distinct from other machines which are constant-stroke machines.

The principal advantage of the constant-load machine is that it causes failure to progress more rapidly after rupture has begun.

Fig. 3 — Hydraulic-Driven Fatigue Testing Machine Designed by Underwood, Capable of Imposing Very High Loads at Small Amplitudes. Mounted in machine is connecting rod, piston pin and piston assembly



Special Fatigue Testing Machines

Another machine is the familiar General Motors fatigue testing machine developed by A. F. Underwood and his associates. (Fig. 3.) The load is imposed hydraulically in this machine, and it is constructed so that very high loads at rather small amplitudes can be imposed on components or assemblies of components. As shown in Fig. 3, the machine contains an assembly of connecting rod, piston pin, and piston. Not only the design, the materials and the heat treatments, but also the effect of fits and clearances in the various individual parts can be evaluated with this equipment.

A recent model can impose a load of 150,000 lb. at a high rate of application. A number of the components of various automotive vehicles and engines now used in the General Motors line have been evolved by testing on this machine.

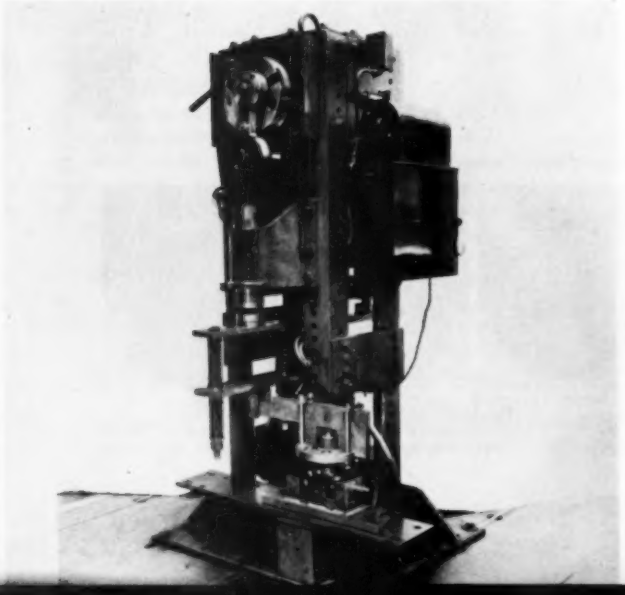
Another component-testing machine is the Chevrolet dual-purpose stroking machine shown in Fig. 4. This machine can be operated either as a constant-stroke or a constant-load machine. It consists of a variable crank mechanism driven through spiral bevel ring gears, and operates through a ram connected directly to a lever which is mounted on the specimen to be tested either directly or through springs.

The specimen being tested in this particular view is a steering knuckle pin. The spindle of the knuckle is held by the part of the fixture which is connected to the stroking lever.

Any substitution of material in vital components is first proved out in such a machine before adoption for production in General Motors plants.

Another general-purpose fatigue testing machine using a similar means for stroking is seen in Fig. 5. This has been used for testing quite a variety of components in the General Motors Research Laboratories, where the machine was developed originally by J. O. Almen. The variable-throw crank is connected to a lever which is fastened to the member under test. A fixture, clamped to the worktable at left rear, holds the specimen. A scale beam is available for calibrating the load required to deflect the arm connected to the crank rod.

Fig. 4 — Chevrolet Dual-Purpose Stroking Machine for Fatigue Testing Full-Sized Components Either Under Constant Stroke or Under Constant Load



A BIT OF METALLURGICAL DETECTIVE WORK

The particular component shown in Fig. 5 is a pitman shaft. The investigation was to determine whether such a shaft (Fig. 6), in a bus that went off the road and hit a concrete pier, had failed *before* the bus left the road or whether it had failed as the result of hitting the concrete pier. The placement of liability hinged on the answer to this question.

Figure 7 shows fractures resulting from various loadings. Figure 7A resulted when the load imposed on the lever arm was 1500 lb., causing failure in a relatively few cycles; 1260 in this instance. Failure in such a few cycles tells us that the load was fairly well up toward the yield strength of the material. The nature of the stress distribution from externally applied loads — and, therefore, the appearance of the fracture — is quite different from that produced in simple laboratory specimens tested in torsion.

The serrated shape of the shaft is responsible for a failure consisting of a large number of radial facets. Progressive failure occurs in each one of those little facets projecting from the serrations toward the center of the piece. As the load is decreased, the pattern of failure changes as we see in Fig. 7B, wherein the load was 1000 lb. and the life was 29,000 cycles. The facets are beginning to blend into larger facets as a result of the decrease in the imposed load.

Fig. 5 — General-Purpose Fatigue Testing Machine Developed by Almen. In the fixture at left rear is a pitman shaft such as shown in Fig. 6

a fatigue failure, and in no way resembles the smooth shear fracture resulting from a one-blow failure.

Finally, Fig. 7E shows the fracture from two overpowering blows. They sheared the serrated end of the pitman shaft completely (Fig. 6). The face of the fracture so produced was very similar to the broken shaft taken from the wrecked bus.

The people who owned the bus claimed that the pitman shaft had broken before the bus left the road and was responsible for the accident. The tests which were run on this particular stroking machine showed that the type of failure that would have had to occur *before* the bus left the road is a progressive type of failure and of an entirely different type from the one which was actually found after the accident.

Attempts have been made to ascribe the difference in these fractures to the quality of the material in the broken member. This series of tests makes it clear that the differences in these fractures are due entirely to the magnitude and the type of loading. The material in all of the tested pitman shafts was identical. It was good, strong, ductile material. This is obvious from the appearance of the fracture produced by the impact test.

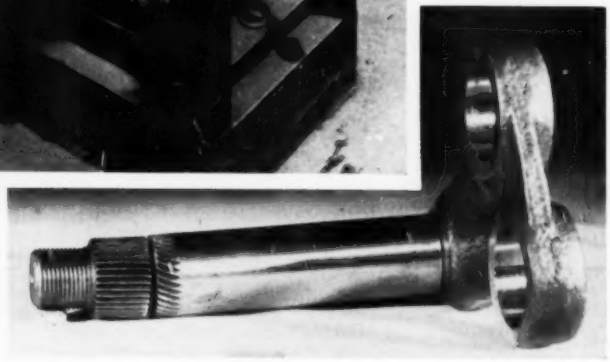
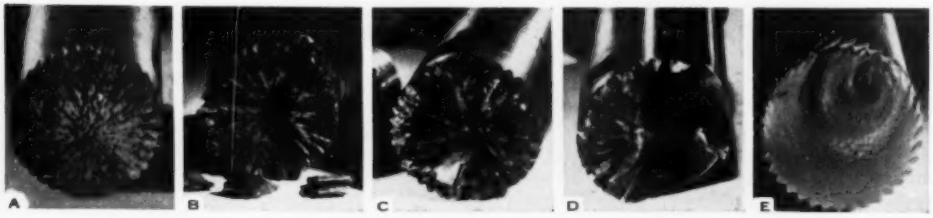


Fig. 6 — Pitman Shaft Fractured by Two Heavy Blows

With still lower loads, blending of adjacent facets is more pronounced as in Fig. 7C and 7D, showing the break caused by 800-lb. and 640-lb. load, respectively. The facets have nearly disappeared in the fracture from 711,670 cycles at ±640-lb. load. This is still

Fig. 7 — Fractures of Pitman Shaft Under Various Loadings



A: Load ±1500 lb.; 1260 cycles to failure
B: Load ±1000 lb.; 29,470 cycles to failure
C: Load ±800 lb.; 119,990 cycles to failure
D: Load ±640 lb.; 711,670 cycles to failure
E: Fracture resulting from two blows of 230-lb. hammer dropped 11 ft. 4 in.

Electro-Machining of Carbides and Other Hard Compacts

By Arthur H. Allen, Technical-Business Consultant, Cleveland

SHAPING, finishing and sharpening single-point cemented carbide cutting tools, milling cutters and dies have accounted for the use of considerable quantities of bort, the crushed material used in making diamond wheels for grinding. Not only are more and more carbide tools being used to finish the tough alloys specified in jet engines, ordnance and other military materiel; there is an additional rising demand for diamond wheels for grinding projectile cores, rifling gun barrels, and finishing compressor wheels and turbine buckets of turbojet engines. As of the moment, however, 75% of the diamond wheels are consigned to the shaping of single-point carbide tools, grinding chip breakers into the tools, and shaping milling cutters and broaches. Since diamond bort is limited in quantity, some means for conserving its supply is most imperative.

To investigate the problem and make recommendations, the Minerals and Metals Advisory Board of the National Research Council recently conducted an inquiry into new processes for machining and grinding, and submitted a detailed report indicating that substantial progress had been made by various industrial and governmental organizations in the field of electro-machining and "grinding" by ultrasonic processes. The following is a summary of the 80-p. report, MAB-18-M, obtainable through the Metallurgical Advisory Board, 2101 Constitution Ave., Washington 25, D. C.

The pinch in diamond bort is revealed by figures which show that inventories in the hands of both manufacturers and dealers declined 8% in 1950 and another 9% in the first six months of 1951. The total amount of bort held in all inventories — not including government stockpile — is less than a six-month supply, measured by current usage. Bort comes from two sources—imports and material reclaimed for reuse. Imports for 1951 approximated 6,220,000 carats, comparing with 5,322,000 carats the previous year. However, usage jumped 1,500,000 carats, making an appreciable dent in inventories.

Granting some increase in imports and reclamation in 1952, the total supply would be insufficient to produce the tools and military items for a greatly expanded mobilization program. In addition, many new military devices, involving hard-to-machine materials, are in the preparatory stages and the anticipated rate of production is high.

Excluding methods involving bonded or coated abrasives, there are several processes under development which eventually may prove acceptable substitutes for diamond wheel grinding, or for machining of materials normally considered unmachinable. The techniques include *(a)* electrolytic, *(b)* electro-sparking, *(c)* electro-arcing, *(d)* ultrasonic, and *(e)* combinations of the foregoing. Except for shaping and finishing dies and a few installations for the "disintegration" of broken taps or reamers lodged in production parts, none of the processes is now in commercial use. Furthermore, no fully proved designs are available for shop tools which can conserve diamond bort. However, machines have been designed for practical evaluation of the electrical processes and for appraising their results in use.

Before substantial savings of bort can be achieved, there must be commercially operable machines based on one or more of the above processes. It is conceivable that some existing machine units might be adapted to one or another of the methods without too much modification. A review of the techniques will throw more light on this.

ELECTROLYTIC PROCESS

Electrolytic grinding usually is done by revolving a metal disk cathode in close proximity to the workpiece, which is the anode, while an electrolyte flushes over the disk and workpiece in the same way that a coolant is applied to a grinding wheel. The system is adaptable to removing stock from electrically conductive bodies such as metals or metal carbides. Applications appear lim-

Electro-Sparking and Electro-Arcing

ited to such items as those possessing small surfaces which must be ground, or in which small diameter, deep holes are to be drilled. In its original form, the process was proposed by a Russian engineer, and several references to it have been noted in Soviet technical literature.

Steady direct current, usually between 16 and 18 volts, and a highly conducting electrolyte are necessary; likewise high current densities at the anode. A succesful practical process hinges on discovery of a suitable electrolyte, and of effective control devices for spacing the cathode and anode, and for flowing the solution into the zone of electrolytic cutting. The action is characterized by low local heating and essentially no consumption of the cathode.

ELECTRO-SPARKING PROCESS

Here, stock usually is removed by making the work one of the electrodes in a properly designed circuit. Rapidly pulsed current of the spark discharge type is passed between the work and the other electrode in a dielectric fluid. The method is especially suited to forming small diameter, deep holes of any shape and is characterized by relatively high electrode consumption. Voltage range is between 40 and 300.

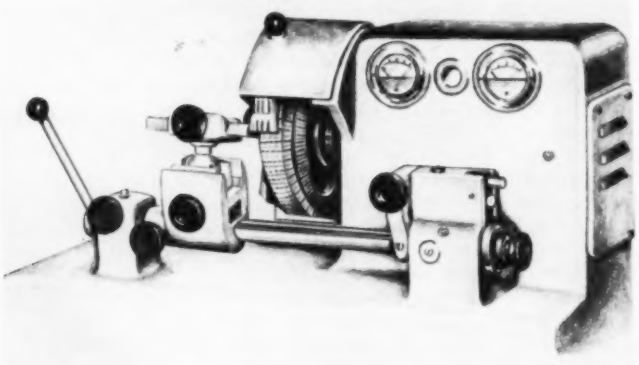
Accuracy and cutting rates are interrelated — 0.0002-in. tolerance at a low cutting rate, for example. Action is quite uniform; internal apertures can be formed in tungsten carbide which leave a surface finish of about 50 micro-in. rms. and 0.003 to 0.004 cu.in. of material is removed per min. It will be noted that this process is electromechanical and not electro-chemical, stock being removed by the impact of electrons and the metal or carbide particles are carried away suspended in the dielectric fluid. At least two companies are engaged actively in research activities that are directed toward the improvement and diversification of this technique.

A machine, illustrated herewith, is probably of this type. It was designed by Norbert Eberle after some preliminary work with Krupp's Vidia Works in Essen, and built by Noxas Union Co. of Frankfurt, Germany. It uses a wheel of ordinary metal — perhaps white iron or hardened high-chromium steel — about 12 in. diameter by 1¼ in. thick. On each face are ground closely spaced radial grooves as well as across the periphery, these being about 0.03 in. wide, 0.06 in. deep, giving the effect of a corduroy surface. Alternating current of 100 volts is imposed between wheel and work; the grooves cause enough vibration to make and break the arc continuously. The result of this metal-removal method is a surface similar to a ground surface with semipolish.

However, a precaution should be observed: A certain amount of metal is transferred from wheel to the surface being ground. To avoid deleterious alloying action, the wheel should be of the same nature as the material being ground, or a powder of correct analysis blown on tool and work.

Another of the electro-machining processes is the cutting by electro-arcing. This is performed by making the work the anode and maintaining an arc between the work and the cathode. Pulsating direct current of less than 25 volts potential is often applied through a moderately conducting electrolyte, such as a waterglass solution. The arrangement is particularly suited to rapid cutoffs of hard metals and carbides, and may be faster than a thin bort wheel. However, a purely electro-arcing process results in somewhat rough surfaces.

Fig. 1 — German Machine for Grinding Flats on Hard Materials Using Metal Wheel With Corrugated Surface and an Imposed Alternating Current



The electrical discharge is initiated by contacting the electrodes, and the current is carried by vaporized metal ions. The process commonly involves the deposition of some nonconducting film (such as silica) on the work; high local heating is evidenced by moderate consumption of the cathode.

ULTRASONIC PROCESS

As differentiated from the electro-chemical and electro-mechanical processes, the ultrasonic technique does not utilize current directly. Cutting or stock removal is accomplished by abrasive action at high frequency and low amplitude. Thus it is possible to process nonmetals or nonconducting materials. The cutting or grinding tool usually is vibrated in the frequency range from 16,000 to 29,000 cycles per sec. through an amplitude of only a few thousandths of an inch. The abrasive, commonly 280-grit boron carbide, is carried in water to the tool and work. The tool itself also wears away during the operation.

Roughing operations, yielding finishes on the order of 25-microinch rms., can be carried out to accuracies of 0.002-in. (or even better if finer grit is used). Low stresses are involved and no local heating occurs; thus ultrasonics avoid thermal cracking, pitting or burned color on the surface of the work.

It is claimed that the process is currently available for the grinding of chip breaker grooves in carbide tools on a commercial basis and at competitive cost. Time of the operation ranges from 30 sec. to 2 min., with a unit tool cost of under 5¢.

COMBINATION PROCESSES

A combination of the electrolytic method and diamond wheel grinding is under development. A metal-bonded diamond wheel is used as the cathode, the diamond particles acting as insulating spacers to separate the work from the wheel, and also as scrapers.

Machines have been designed for grinding by a combination of electrolytic and electro-arcing actions. The same electrolyte may serve the same equipment adapted to either process. It may even be possible to combine all three electro-actions in a single machine, and improve the results. While not yet tested, the idea of combining the ultrasonic technique with one of the electro-methods is not being discounted.

Investigators at Frankford Arsenal have been studying an electro-cutting procedure which may be adapted to the cutting and grinding of single-point and form-cutting carbide tools. The cemented carbide is connected in a direct-current circuit as the anode, and held in contact with a rotating mild steel disk (cathode), both immersed in a sodium silicate electrolyte. Either grinding or cutting results, depending upon whether the carbide is held against the side or the edge of the disk. In grinding, it is believed that electrolytic, electro-deposition, electro-sparking and electro-arcing phenomena are all involved to some extent.

A leading machine tool builder has been commissioned to build equipment which will incorporate principles of the method to handle the following: Straight cutoff and shaping; straight, radial and form grinding or polishing; boring, and grinding of chip breakers. Ground finishes of better than 5 micro-in. rms. are anticipated.

If the operation of sharpening single-point carbide tools is limited to flat, off-hand grinding, then only the electrolytic method, or combinations of it with abrasive grinding, appear promising. Conventional grinders using metal-bonded diamond wheels can be converted to handle the operation through the addition of auxiliary equipment such as a rectifier and a pump for electrolyte. In fact, eight conventional types of grinding machines now are being so converted for this combination of diamond wheel scraping and electrolytic action. Performance and cost have yet to be established.

In consideration of the disclosures of this document, four recommendations were formally appended by the Minerals and Metals Advisory Board of the National Research Council urging that:

1. The military services should explore the application of these new processes to relieve potential bottlenecks or shortages, and allocate or seek funds to further these objectives where government incentive is required.

2. Industry should be encouraged to accelerate its efforts in research and in machine development and testing, with the object of bringing these processes into industrial use as soon as possible.

3. An educational program should be

(Continued on p. 142)

A BIOGRAPHICAL APPRECIATION

FRANK P. GILLIGAN

Secretary-Treasurer, Henry Souther Engineering Co.
Pioneer in Steel Specifications

A Biographical Appreciation

NO ENGINEERING degree appears in the *vita* of Frank P. Gilligan. Yet as a young man he was exposed to a metallurgical education that was unique, thorough and priceless — and he was gifted with the mental apparatus to take full advantage of it.

Hartford, Conn., at the turn of the century was the center of the sewing machine and bicycle industries. Hartford was also the headquarters of Henry Souther, a farsighted consulting engineer, who, in a period when metallurgy was more or less of a laboratory curiosity, was to rationalize it into a necessary manufacturing adjunct. Frank Gilligan was an ambitious young man with a good classical and business education obtained under the sturdy hands and minds of New England teachers. In 1903, Henry Souther hired Frank as a stenographer and laboratory assistant.

Immediately perceiving that a man of exceptional mental talents had entered his domain, Mr. Souther proceeded to transmit his chemical and metallurgical training to this young and thirsty mind. The training extended far beyond mere technical aspects, for he ground and polished his enterprising secretary in the use of vivid English expression, encouraged him to study history and economics and literature.

Accompanying Mr. Souther as secretary, Frank wrote, from shorthand notes, the official reports of meetings and conferences with the leading engineers of that day. Howe, Campbell, Sauveur, Richards, and White (of Taylor-White fame) were among the brilliant visitors whose words he transcribed and studied.

The bicycle era declined, but the automobile moved in, with Hartford as the seat of its early development. Still regarded by Gilligan as "a thrilling and enlightening experience" was the assignment to report on the annual automobile show for one of the trade papers. This opportunity to study mechanical and material aspects of early automobiles was not wasted!

It was a natural development that the engineers representing the 28 licensees under the Selden patent (known as the Mechanical Branch of the Association of Licensed Automobile Manufacturers) should decide to meet monthly at the laboratory of the Henry Souther Engineering Co. in Hartford to direct a research and development program. Here the young laboratory assistant participated in the testing of engines, fuels, lubricants, steels and their heat treatment, and other metals then used in the automobile. Here the first steps were undertaken for standardization of screw threads, rims and tires, and associated problems. A limited schedule of steel compositions and recommended heat treatments for automobile construction was prepared and eventually became the basis for the S.A.E. steels.

This happy combination of circumstances was brusquely interrupted when Henry Ford defeated the Selden patent in 1909. But a small group of keen-witted engineers who congregated socially as an informal "Society of Automobile Engineers" promptly converted their social group into a technical body — and the Society of Automobile Engineers (now Automotive Engineers) was born.

With the passage of time Gilligan was assigned to observational duties in the plants of clients, and such work gradually expanded into advisory and consulting service on the selection, inspection, and heat treatment of steels. The practice was broad and ranged from small arms, ball and roller bearings, to machine tools, agricultural implements, ordnance matériel, and foundry practices.

This experience was utilized by the Society of Automotive Engineers in 1918 when he was appointed chairman of the Iron and Steel Division — a tour of duty that extended to 1945 (except for a three-year intermission in 1925-28).

Frank Gilligan's A.S.M. membership dates back to 1920, the year that the old Steel Treating Research Society and the American Steel Treaters' Society amalgamated to form the American Society for Steel Treating at the first convention in Philadelphia. An associate recalls a hot, poorly lighted and poorly ventilated assembly room where Frank, although an official delegate from Hartford, was comparatively unknown among the several thousand men present. Before that convention closed, his active and constructive participation in the activities marked him as a man to heed. The following year he was elected national president of the flourishing young society.

Gilligan's other extracurricular activities over the succeeding years are impressive. He was a member of the Ordnance Department's Metallurgical Advisory Board

A Biographical Appreciation

continuously from 1921 to 1943 (vice-chairman of the Ferrous Board, 1938-43); member of the Joint Committee (U.S. Army, Navy, A.S.T.M., S.A.E., American Railway Engineering Association, and American Association of Steel Manufacturers) investigating effect of phosphorus and sulphur in steel, 1919-30; member of the engineering division, National Research Council, 1921-24; member of the Committee on Fatigue of Metals, 1919-27; and president, Hartford Engineers Club, 1924-25. There was also time for civic duties as member of the Town School Committee (Windsor, Conn.) and Board of Finance and Borough Council (Farmington).

The years when Frank Gilligan and Henry Souther (long since deceased) worked together laying the groundwork for automotive developments marked the period when metallurgists of the general practitioner type were being supplanted by specialists. Yet, although Gilligan possesses the capacity to become such a specialist, nature and environment destined him to become a moderator, a counsellor, an organizer, and a coordinator of such experts. Anyone who has seen and heard him preside at a meeting is impressed with the firmness with which he directs and holds discussion to the subject at issue, his ability to filter out the extraneous, and present a vivid summary. His personality lifts him naturally and instinctively to the top. He dominates pleasantly through sheer inner force.

The foundation of every outstanding mind is a retentive memory. An omniverous reader on a wide variety of subjects, by no means confined to technical matters, Frank absorbs the main argument, sifts and discards the trivial, and apparently retains the salient features for all time.

A friend tells of consulting him on some obscure point in metallurgy, and being told, "I think you will find what you are looking for in an article by — let me see — J. H. Whiteley, published in the Iron and Steel Institute — 1922, if I recall. About page 335." Actually, the article appeared on page 339 — and it was some 20 years since he had read it!

This same friend concludes: "In 30 years of more or less close association with Frank Gilligan I have never known him to lose his temper. I have never known him to call a man down. He inspires men to greater effort, gives them responsibility judiciously. Many men owe their advancement in industry to him. He has an abiding faith in human nature. Of men he hears, thinks, and speaks no evil. He's a man to ride the river with."

Correspondence

Early History of Steel Extrusion

DETROIT

"Critical Points" in the May issue of *Metal Progress* carries a brief account of the cold extrusion of steel shells as a manufacturing process for artillery projectiles and rockets. A little history of this thing may give some interesting background.

In 1930 the Parker Rust Proof Co. sent "Bonderite", its phosphate coating, to Metallgesellschaft, our German licensee. Whereas, in the United States its chief use lay in extending paint life on metal as a corrosion-resistant paint base, the Germans employed it principally in drawing and cold extruding of steel. By these applications the Germans were able to manufacture armament, such as shell, cartridge cases, and so on, which the other countries made at that time from brass and critical alloys.

Parker's men visited Germany in 1937, saw this use of Bonderite, and attempted to introduce it to American industry. However, the United States was not then short of copper, brass and other materials for which the Germans were substituting low-alloy steel, and consequently the application did not find a need requiring its immediate acceptance.

American tube mills, however, gradually were taught its advantages in the economical drawing of tubes, and in 1940 or 1941 started to use this technique. Today 90% of all cold drawn seamless steel tubing

is treated with Bonderite as an aid in drawing. In addition, millions of feet per year of welded tubing (including tubing made by electric resistance welding) and cold drawn seamless tubing of carbon steel are produced with the aid of Bonderite.

After the war, because of the wide publicity given to the German cold drawing technique, American industry became interested, and the U. S. Government brought two technicians from Germany to work on projects. These technicians came from Parker's German licensee, Metallgesellschaft, and they brought with them, naturally, the phosphate coating material which we had sent to Germany in 1930.

F. J. DeWitt
Vice-President
Parker Rust Proof Co.

Effect of Cr on Eutectoid Carbon

Jersey City, N. J.

A number of investigators have given quantitative estimates of the carbon content of eutectoid pearlite in the chromium steels. Thus, Monypenny on p. 36 of his book "Stainless Iron & Steel", plots a smooth curve to show this relation, and Reed in A.S.M. *Transactions* for August 1932 deals with the "Influence of Special Elements on the Carbon Content of the Iron-Carbon Eutectoid". A résumé of the then available data is given in Greaves' book "Chromium Steels", p. 74 to 76. Edgar C. Bain shows curves for the effect of elements on p. 127 of his book, "Alloying Elements in Steel".

Effect of Cr on Eutectoid Carbon

The purpose of this letter is to propose a simple empirical formula which approximates the values reported by the various investigators — Monypenny, Bain, Reed, Russel, and Aall:

$$\text{Plain Chromium Steels} = \frac{\text{\% Carbon in Eutectoid of}}{\text{\% Cr} + 7} = \frac{6}{\text{\% Cr} + 7}$$

Calculated results from this formula and the data shown by the various authorities are given in the table.

It will be observed that the proposed formula checks Monypenny's curve very closely. The calculated results are fairly close to Bain's data up to 7% chromium; for higher percentages the calculated values are lower. Reed's data also follow closely up to 8% Cr; for the range 8 to 10.5% Cr Reed shows two values, one of which agrees with the calculated value. Russel's values are also in general agreement, although somewhat high for chromium contents below 5%. Aall's results fall in line up to 9% Cr, but above this composition they drop sharply in comparison with the calculated value.

H. S. Blumberg
Chief Metallurgist
The M. W. Kellogg Co.

Per Cent Carbon in Eutectoid of Chromium Steels

% Cr	Calculated From Formula	Values Quoted by Various Authorities				
		Monypenny	Bain	Reed	Russel	Aall
0	0.86	0.88	—	0.90	0.90	0.90
1	0.75	0.75	0.70	0.77	0.81	0.84
2	0.67	0.66	0.62	0.65	0.74	0.77
3	0.60	0.60	0.57	0.54	0.67	0.71
4	0.55	0.55	0.53	0.50	0.60	0.65
5	0.50	0.52	0.50	0.47	0.55	0.58
6	0.46	0.47	0.48	0.45	0.50	0.52
7	0.43	0.44	0.46	0.42	0.45	0.46
8	0.40	0.39	0.44	0.34 ?	0.39	0.39
9	0.37	0.37	0.42	0.36 ?	0.35	0.33
10	0.35	0.35	0.41	0.33 ?	0.31	0.27
11	0.33	0.32	0.40	—	0.27	0.20
12	0.32	0.30	0.39	—	0.25	0.14

Porous Metal

Glen Cove, N. Y.

We are very much interested in the letter written by George Atwell Richardson (see *Metal Progress* for March 1952, p. 81) suggesting that porous metals be used for jet engine rotor blades, because we have already developed and made available for commercial use a porous material suitable for this purpose.

This alloy is normally fabricated in stainless steel and in higher alloys. It can be made to have minimum tensile strength of 40,000 psi., with porosities variable over a wide range, including the range which would be required for rotor blades. Furthermore, it is readily possible to vary porosity over the surface of a single blade so that the cooling can be concentrated where required.

Tensile strengths are available in the neighborhood of 35,000 to 55,000 psi., depending upon the flow

range. These would have 75 to 90% of the density of solid metal. Pore openings are in the range of 1 to 10 microns. Material can be formed about radii corresponding to an elongation of 10 to 12% or more, and to still smaller radii with intermediate anneal. Material can be readily reinforced to still higher strengths by inserting mesh or solid grids.

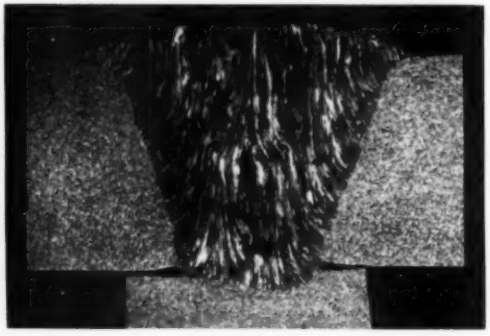
DAVID B. PALL
Micro Metallic Corp.

Macrographs of Austenitic Welds

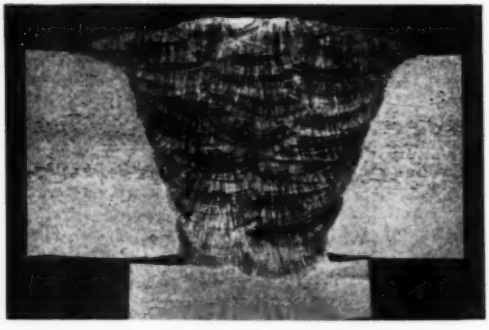
PHILADELPHIA

We noted with interest the macrographs of two austenitic welds submitted by M. A. Scheil and published in the February issue of *Metal Progress*. Mr. Scheil's description of these left the impression that some austenitic welds show a beaded structure and others are of a dendritic nature.

Dendritic Structure of Weld Revealed by Etching With Hydrochloric Acid and Ferric Chloride



Same Weld After Polishing and Etching in Boiling 1:1 Hydrochloric Acid Shows Bead Structure



It has been our experience that both structures may be revealed in the same weld by using different etching reagents. This is shown in accompanying macrographs. The dendritic structure was revealed by etching with a saturated solution of ferric chloride in hydrochloric acid which was applied by swabbing. This was removed by polishing on emery paper and the specimen was immersed in boiling 1:1 hydrochloric acid to show the bead structure, the dendritic structure being faintly visible.

The welds were made in Type 347 plate and were deposited with Type 347 electrodes.

We are interested in hearing of the experience of other readers on this matter.

LORIN K. POOLE
Project Engineer
Arcos Corp.

Comments on U.S. Welding

DÜSSELDORF-OBERKASSEL, GERMANY

It was amazing to me the friendly way superiors and subalterns cooperate in your plants and the informal way your engineers and plant personnel address each other. Perhaps it is easier in the English language than in the German to address someone by his first name, except that in England, where they speak the same language, this condition does not exist. Such treatment of equality is typically North American and shows a mental attitude of your people for which I have the highest admiration; I have the impression that it is to the best advantage of the American industry.

I believe your country has made great progress in welding during the last 15 years, especially in automatic welding with the Union-melt process. Also, you have developed and advanced the production technique using inert-gas-shielded welding for metals difficult to weld, such as stainless steel and light metals. Without doubt there are fields in which welding is applied less in the United States than in Europe, and especially in Germany. For instance, we in Germany have welded much greater bridges than you have in your country. Of course I had the impression that this was not the fault of your welding engineers, but probably the fault of your slightly antiquated construction laws.

Regarding my own specialty, the production of welding electrodes, I had the opportunity to talk with different engineers in

your plants and to notice that at present your methods of manufacturing are superior. The quality of the American electrodes, in my opinion, is about the same as those of European and German origin.

It would take too long to mention more details, but I can tell you that I am now corresponding with a couple of American engineers, and I am convinced that this kind of cooperation will bring advantages both to your people and ours.

EGON KAUHAUSEN
Chief Engineer
Welding Wire and Electrode Factory
Gebr. Böhler & Co.

Defends Use of 0.50 C Steel for Springs

DETROIT

Mr. Zimmerli in his article "Metals Used for Mechanical Springs" (May 1952, page 97) gives the lower material cost as the only reason for using 0.50% carbon steel in springs, and mentions spotty hardening as a condition that could be expected in material over 0.035 in. thick. I don't believe this gives a true picture of this material's place in spring manufacture — we have been using 0.50% carbon strip for years, primarily because of its greater ability to withstand forming strains without cracking.

We have had no difficulty in hardening 0.064-in. strip containing 0.47 to 0.53% carbon and 0.60 to 0.90% manganese to a Rockwell C-60. Parts that will form consistently without cracks from steel in this carbon range will show an occasional crack when the carbon content is 0.57%, and the number of cracked parts will increase rapidly with the use of higher carbon strip.

N. C. TALMAGE
Chief Engineer
L. A. Young Spring & Wire Corp.

Clarifies Remark on 0.50 C Steel

PLYMOUTH, MICH.

It is quite true that many springs can be made of 0.47 to 0.53% carbon steel with 0.60 to 0.90% manganese content as Mr. Talmage states.

However, what the author meant to convey was that we were dealing with a steel with a carbon content which had to be ordered less than 0.50% to avoid the charge for "extras". Consequently, one tried to specify 0.40 to 0.50% carbon.

The result is that the lower limit often becomes about 0.37% carbon. We look at 0.47 to 0.53% carbon steel as a typical S.A.E. 1055 on the low carbon side when the usual tolerances are allowed between mill and customer differences in the chemical analyses.

We have had heats running 0.38 and 0.52% Mn which had a low apparent hardenability and caused trouble due to a spotty condition. As a corollary of this, we should have stated that the corrugated spring produced at Buick described on page 98 (May issue) was finally made of S.A.E. 950 steel. In the long run, a 1020 steel could not be given the 0.45 carbon content mentioned and satisfactorily harden under the condition stated. Hence steel of different characteristics had to be employed.

It is regrettable that this lack of clarity led to misunderstanding. Mr. Talmage and I are talking about different steels in that the mean carbon content is at least 10 points apart.

F. P. ZIMMERLI
Chief Engineer
Barnes-Gibson-Raymond Div.
Associated Spring Corp.

Embrittlement in Plated Steel

MARIBYRNONG, AUSTRALIA

We have recently seen two interesting examples of damage done to steel parts by hydrogen generated during electroplating operations. In each instance the defects show marked directionality.

Example 1 is a deep-drawn component, cadmium plated, which had extremely low ductility at right angles to the direction of drawing and had fractured with a very slight amount of bending. The item, a smoke bomb container, is shown at $\frac{2}{3}\times$ in Fig. 1. In the other direction, however, the steel could easily be bent over a small radius without failure. A micrograph at 75 × of the end of one of the cracks is shown in the inset of Fig. 1. Susceptibility to embrittlement was caused by failure to stress-relieve the part after deep drawing.

In example 2, small blisters — up to ¼ in. in diameter — developed in a chromium-

Figure 1

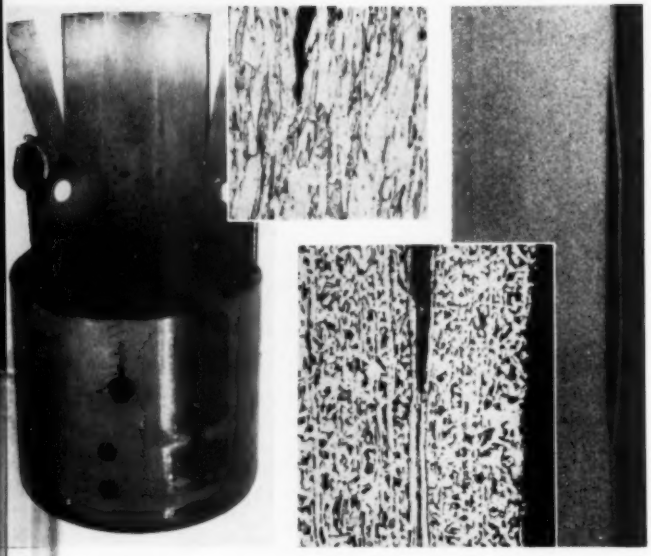


Figure 2

plated piece of ¼-in. mild steel plate. Figure 2 shows a typical blister at 7.5 × and the inset is a 75 × micrograph at the edge of the blister after stripping off the chromium. The blister is associated with a slag-filled ferrite band, which clearly has provided the latent weakness necessary for embrittlement failure. The effect of the hydrogen produced in plating may have been intensified in this instance by the chromium plating bath having an abnormally high sulphate content, the sulphate ratio being 28:1 instead of 100:1 which is usually recommended. We were not able to further investigate the possible effects of high sulphate contents on the severity of hydrogen embrittlement.

JOHN J. DALE
Defense Research Laboratories

Discard This Etchant Promptly

SCHENECTADY, N. Y.

The well-known etchant for stainless steels, "mixed acids in glycerol" (20 ml. concentrated HF, 10 ml. concentrated HNO_3, 30 ml. glycerol), is unstable, and improper handling may result in severe acid burns, although the etchant is recommended without any precautionary note by the ASM Metals Handbook (1948 edition, p. 395) and for the study of sigma phase by E. J. Dulis and G. V. Smith.

When made up, used in the usual manner, and *discarded soon afterward* it is indeed safe and no special precautions are necessary. When left standing in glass or porcelain ware for extended periods a violent bubbling reaction, with copious acid spray, will suddenly start. The reaction is highly exothermic and evolves red fumes of nitrogen dioxide. The dormant period and the degree of violence depend on the ambient temperature as well as whether any stainless steel is in contact with the solution.

In a series of tests we found that at about 20° C. the etchant alone in a beaker did not react until after 18 hr. and it was not very violent. At an ambient temperature of about 30 to 35° C., which can easily occur in a fume hood, the etchant in a beaker reacted after 8 hr. and in as violent a manner as when the etchant is near boiling. At 100° C. the reaction will occur after 1 min.

If stainless steel is immersed in the solution, the violent bubbling reaction will occur at 20° C. after 3 to 4 hr.

A boiling solution containing two parts of HF to one part of HNO_3 (both concentrated) did not evolve NO_2 fumes, but did so on contact with stainless steel. The action is more violent when glycerol is also used.

Probably both the "aqua regia" type of reaction and the reactivity of nitric acid with organic compounds are involved in this instability of the etchant. Just prior to the buildup to a violent rate, when no metal is present, the bubbling can be observed to originate from the silicon compounds which have settled to the bottom of the glass beaker. Catalysis of the reaction by these silicon compounds or by metal ions, when they are present, appears to play a part in the reaction. Since this reagent would react with glass or glazes, it was never retained after first use, but with the increased use of polyethylene ware for hydrofluoric acid solutions, the etchant has been kept in them for times longer than the dormant period. This practice should be avoided.

L. H. SATZ
Metallurgical Engineer
General Engineering Laboratory
General Electric Co.

COMPARISON OF GRATE MATERIAL

Gray iron sintering grates, at left, show bad scaling and warpage after a single month of use.

Note good shape of Ductile Iron grates, above, after same service. They greatly outlasted gray iron grates.

DUCTILE IRON FURNACE DOORS SAVE MONEY, TIME AND LABOR—In ordinary iron, exposed to high temperature, internal oxidation easily penetrates along paths of flake graphite, thus causing destructive growth. Penetration is curbed in Ductile Iron, since its graphite is wholly in spheroidal form.

DUCTILE IRON Sintering Grates and Furnace Doors

excel in elevated temperatures

Performance Records Show Outstanding Heat-Resistance of this New Material.

Tests show that iron containing graphite wholly in spheroidal form provides notably greater growth resistance than ordinary gray iron.

FOR INSTANCE: Gray iron and Ductile Iron grate bars in the Greenawalt sintering system of a merchant pig-iron producer gave the following performances:

At the Canadian Furnace Company, Ltd., in Port Colborne, Ontario . . . from date of their installation, August 1950, to June 1951 . . . no Ductile Iron grates needed replacements although 150 gray iron grates had to be replaced after 6 weeks' service.

The sinter-plant foreman stated, "*The Ductile Iron grates still seem to be as good as new.*" Cast by Lakeside Foundry, Ltd., of Port Colborne, these Ductile Iron grates also out-performed steel grates tested previously.

ANOTHER EXAMPLE: The forging furnaces of a leading steel plant now have Ductile Iron doors supplied by United Engineering and Foundry Company, Pittsburgh 22, Pa. Gray cast iron doors which were subjected to 24 hours' continuous service daily, heat-cracked after an average life of about four weeks. A trial lot of annealed Ductile Iron doors lasted 17 weeks . . . or more than four times as long as those of gray cast iron.

APPLICATIONS: As cast, as well as heat-treated Ductile Iron parts . . . serving at elevated temperatures in scores of machinery, engine and furnace applications . . . provide a growth-resistance heretofore unavailable in gray cast iron.

AVAILABILITY: Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing Ductile Iron under patent licenses. Request a list of available publications on Ductile Iron . . . mail the coupon now.

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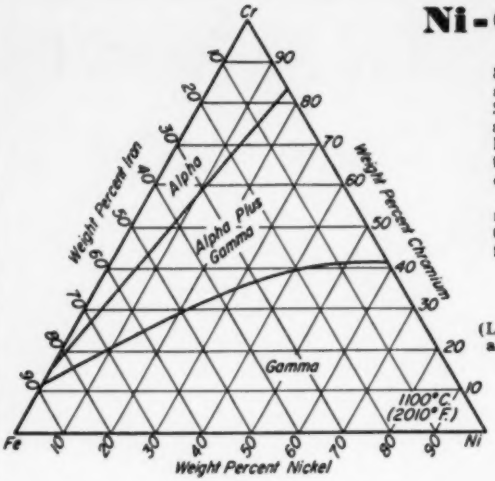
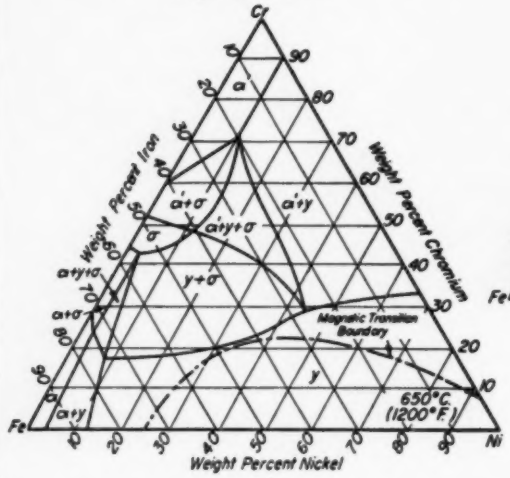
Ni-Cr-Fe Ternary Diagrams

Isothermal diagrams showing phase boundaries at 1100, 800 and 400° C. are adapted from publications of J. W. Pugh and J. D. Nisbet ("A Study of the Iron-Chromium-Nickel System", *Journal of Metals*, A.I.M.E., February 1950, p. 268) and W. P. Rees, B. D. Burns and A. J. Cook ("Constitution of Iron-Nickel-Chromium Alloys at 650 to 800° C.", *Journal* of the Iron and Steel Institute, July 1949, p. 325). All isothermal diagrams are for alloys of a high degree of purity.

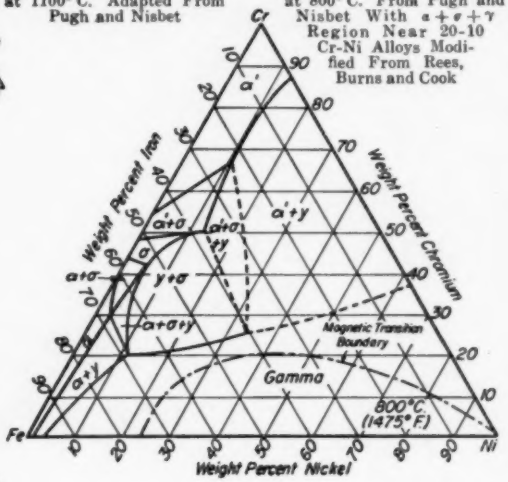
The diagram in the lower left corner shows stable and metastable phases in quenched alloys containing about 0.10% C. (Nitrogen is comparable to carbon in austenite-forming power.)

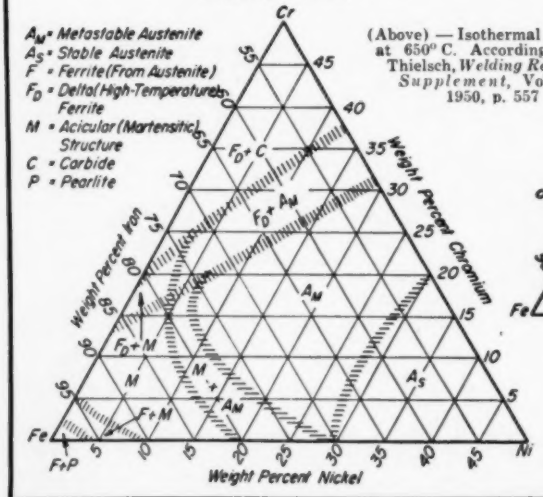


(Left) — Isothermal Section at 1100° C. Adapted From Pugh and Nisbet

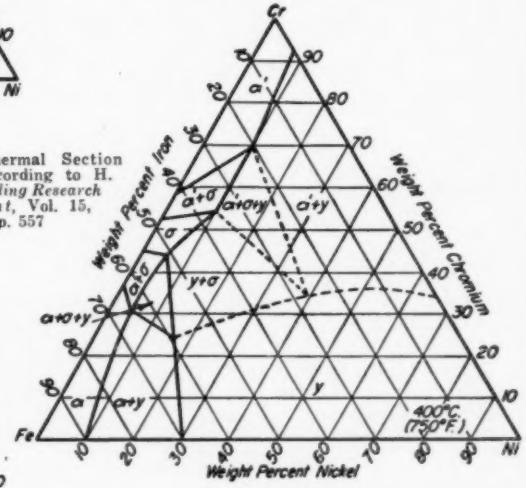


(Left) — Isothermal Section at 800° C. From Pugh and Nisbet With $\alpha + \sigma + \gamma$ Region Near 20-10 Cr-Ni Alloys Modified From Rees, Burns and Cook





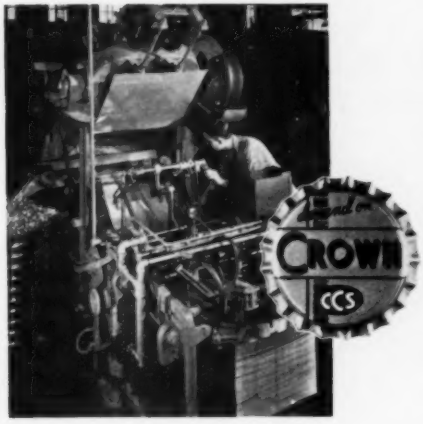
(Above) — Isothermal Section at 650° C. According to H. Thielsch, *Welding Research Supplement*, Vol. 15, 1950, p. 557



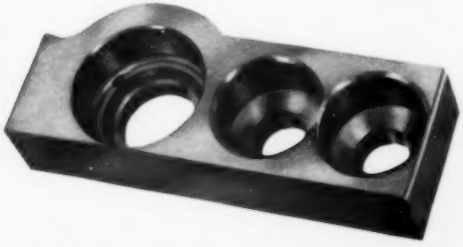
(Above) — Isothermal Section at 400° C. According to Pugh and Nisbet

(Left) — Phases Existing in Alloys Containing About 0.10% Carbon After Quenching From Maximum Amount of Gamma Phase (About 1100° C.). E. C. Bain and R. H. Aborn, "Metals Handbook", 1948 Edition, p. 1261

Crown Cork and Seal Company Eliminates Die Holder Failures, Increases Production by Martempering with AEROHEAT® HEAT TREATING COMPOUNDS



THE MACHINES—Large presses like this cut and form bottle crowns in one operation at the Baltimore, Md., plant of Crown Cork and Seal Company.



THE PARTS—Intricately designed die holders like this are made of an oil-hardening, non-deforming tool steel. They are brought up to 1500°F in AEROHEAT 1200 and held for 20 minutes, transferred immediately to AEROHEAT 300 at 450°F for 25 minutes and then air cooled. A final tempering in AEROHEAT 300 at 625°F for two hours follows. Finished hardness is Rockwell C50-55.

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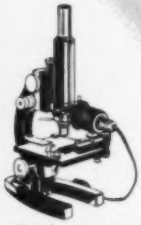

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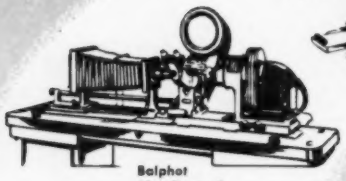

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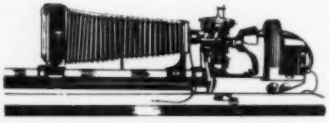

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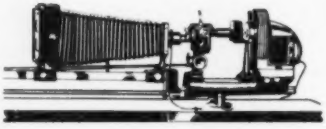

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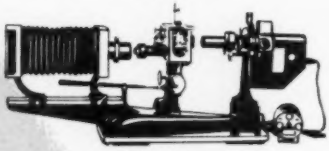

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The Metal Germanium and Its Use in the Electronics Industry

By Anthony S. Rugare, Engineering Section, Electronics Dept., General Electric Co., Clyde, N. Y.

IN RECENT YEARS germanium has come to the fore as an important "semiconductor". As such it has given us the solid rectifier or germanium diode. Each month about 200,000 diodes are produced, of which a major fraction goes into radar and other military and commercial devices, and a minor fraction into television sets. Another electronic device using germanium now made in great numbers is a triode called the transistor, a small specimen of suitably treated germanium with three electrical contacts, roughly similar to the triode electronic tube in performance and application, but it requires no filament power, has indefinite life, and is no larger than a match head. Finally, germanium is "optically transparent" to infrared radiation, and may be used in telescopes or microscopes for such short wave lengths — for example in infrared spectroscopy.

It would be well to define some of these terms briefly at the very outset of an article intended for metals engineers. As a matter of fact, it would doubtless be equally important to introduce them to the metal germanium, which goes unmentioned in most texts on general metallurgy.

The American supply comes as a by-product of the zinc smelting operations in the Missouri-Oklahoma-Kansas region. These zinc sulphide ores are contaminated with a little of the sulphides of the next two heavier elements in the periodic sequence, gallium and germanium. These sulphides are converted to oxides along with the zinc in the preliminary roasting operation. The calcine, as is well known, is then mixed with anthracite coal and retorted, the zinc distilling off as metallic vapor at 2000 to 2400° F. Most of the other elements in the charge (including germanium) have such low vapor pressures at those temperatures that they remain behind in the residue.

Separation of germanium (and gallium) from zinc residues is done by leaching in an excess of commercial hydrochloric acid, and filtering off the lead chloride and other insolubles. Germanium and gallium are then precipitated from the hot solution after neutralizing by the slow addition of zinc oxide. The germanium is separated from gallium by distillation of the volatile tetrachloride. This is then hydrolized with water and the precipitate (pure GeO_2) is the raw material for the further processing to be described. It is a dense white powder which melts to a clear nonvolatile liquid at a temperature of 1875° F.

Commercially there are several different schemes for reducing pulverulent dioxide, but basically all convert it into a grayish metal powder by heating in pure, dry hydrogen at about 1185° F. in equipment such as shown in Fig. 1. This powder, when melted under argon and cooled at a proper rate, results in a very brittle grayish white metal. It exhibits a metallic reflection and a crystalline upper surface. This material, when carefully processed as will be described in some detail later, is the metal from which the pellets used in the manufacture of solid rectifiers are cut.

Some of its known properties are

Atomic number	32
Atomic weight	72.60
Specific gravity	5.36
Specific heat	0.072 cal. per g. per °C.
Melting point	940° C. (1725° F.)
Boiling point	2700° C. (4900° F.)
Crystal lattice	Diamond cubic

It is so extremely brittle that no definite figure for indentation hardness can be quoted.

Oxygen does not appreciably react with germanium below 1100° F. In fact, the metal reacts but slowly to many strong reagents, resisting 50% NaOH, concentrated and 1:1 HCl, 1:1 H_2SO_4 or water for one week at 70° F. or 8 hr. at 195° F.

A solution of 10% NaOH or concentrated HNO_3 will tarnish the metal. More dilute nitric acid forms germanium dioxide on the surface of the metal, while a mixture of concentrated H_2SO_4 and HF slightly attacks the

Characteristics of Semiconductors

metal itself. A form of the latter treatment is used in the preparation of germanium pellets for solid rectifiers.

Semiconductors — Although the element germanium has been known to chemists for 75 years, the metal was a rarity until perhaps 15 years ago when radar was being intensively developed. Its peculiar properties as a semiconductor made it invaluable as a detector of microwave frequencies.

Generally speaking, a semiconductor has electrical properties intermediate between those of insulators and metals. The elementary semiconductors which have been investigated to date are boron, silicon, germanium, selenium and tellurium, which the metallurgist will recognize as elements in that nebulous region separating the metals from the nonmetals. One of the most pronounced characteristics of semiconductors is a decrease of resistivity with increasing temperature in certain temperature ranges, together with an increase of resistivity in other ranges.

A basic understanding of the difference in electrical conductivity of metals, insulators and semiconductors may be had by considering the arrangement of electrons in the atoms of elements. The popular and simplified conception of the structure of an atom is one picturing the most of the mass concentrated in a small nucleus having a positive charge surrounded by a solar system of negative particles of electricity (electrons) equal in number to the atomic number of the particular element involved.

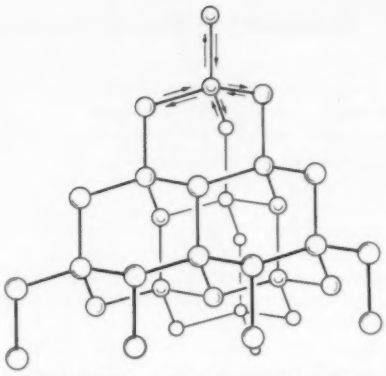
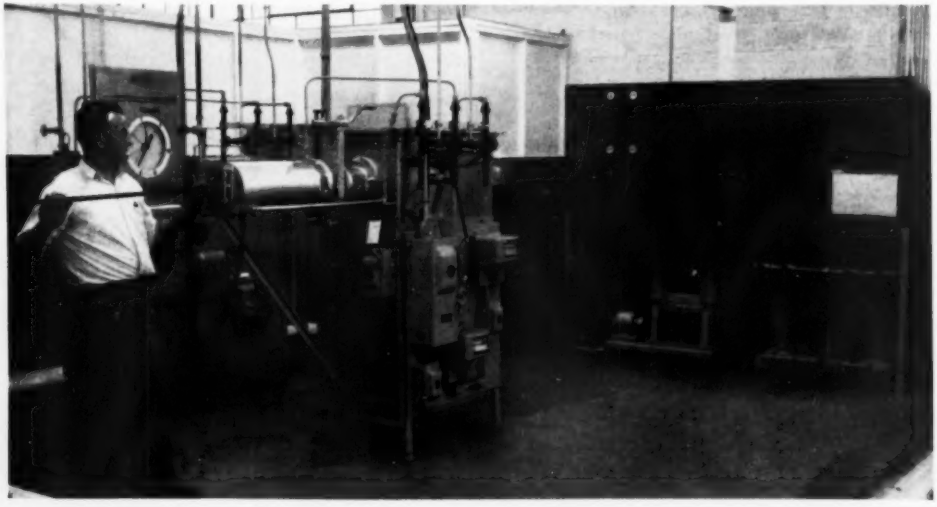


Fig. 2 — Diamond-Cubic Crystal Lattice, Where Each Atom Has Four Equidistant Neighbors. All electrons in a quadrivalent metal like pure germanium are closely engaged, as indicated by arrows around the top cluster (crystallographic unit)

These electrons are arranged in "shells", each completed shell having a system of particles in equilibrium. (The positive charge carried on the nucleus equals the total of the negative electrons surrounding it.) Consider the inert gases. Helium, element 2, has two units of positive electricity as the

Fig. 1 — Loading a Charge of Germanium Dioxide Into a Furnace With Hydrogen Atmosphere for Reduction Into Metal. Control panels and gas purification system in the background



nucleus and two electrons in its first shell, and these form a system in equilibrium — the electrons have no tendency to wander away or to link up with other elements. Helium is therefore inert, chemically. Neon, element 10, has this shell of two electrons plus the second shell of larger mean diameter with eight electrons in equilibrium. None of these eight tend to wander away.

Fig. 3 — Mobile Electrons Occur in Germanium When a Few Atoms Like Arsenic (With Five Electrons in the Outer Shell) Are Introduced Into the Crystalline Lattice. This produces "n-type" conductivity; the proper impurities are called "donors"

The next heavier elements beyond the inert gases are strongly metallic, while those preceding are electrically nonconducting. The following list is indicative:

Next Lower	Inert Element	Next Higher
	$_{2}He$	$_{3}Li$
$_{9}F$	$_{10}Ne$	$_{11}Na$
$_{17}Cl$	$_{18}A$	$_{19}K$

While the arrangement of the outer electrons in an atom of an inert gas is an especially stable one, an atom of an element following an inert gas in the periodic table will contain an extra electron outside of an inert-gas core. In the solid state these extra electrons, sometimes known as valence electrons, may easily come loose under the attraction of neighboring atoms, giving rise to electrical conduction when they are impelled in a certain direction. Physical metallurgists sometimes speak of an "electron cloud" to explain the property of high electrical conductivity.

On the other hand, atoms of elements *preceding* the inert gases in the periodic sequence could arrange their electrons as they are arranged in the inert gas if they had an additional electron. They exhibit a tendency to pick up an extra electron but in the solid state there are no electrons with a tendency to become free. Such a condition restricts electrical conductivity and is characteristic of an insulator.

So much for the conductors and the insulators, but there are also elements which behave neither as metals nor insulators. Two of them have been studied intensively, silicon (element 14) and germanium (element 32), the one directly under sodium in the periodic sequence. They are both in Group 4b of the periodic table, normally exhibiting a valence of four and forming dioxides, and both crystallizing in the diamond cubic system (interlaced face-centered cubic lattices). We will concentrate the rest of the discussion in this paper on the second one of the two, namely, germanium.

Germanium, element 32, has 32 electrons, ranged in three shells in equilibrium containing 2, 8, and 18 each, plus four in an unsatisfied fourth shell. Thus it has four valence electrons and forms tetrahedral bonds. Figure 2 is a perspective of the crystal structure where the atoms in the background are shown progressively smaller than those in the foreground, and the binding forces by heavier lines in the foreground. It will be seen that in this system each atom is surrounded by four others, equidistant. Each bond (valence electron) may be thought of

Fig. 4 — "Holes" Occur Somewhere Near Each "Acceptor" Atom (Having Only Three Electrons in Outer Shell), and "p-Type" Conductivity Results

n-Type Versus p-Type Conductivity

as reaching out toward a near neighbor. This structure would therefore have no free electrons, and hence would be a very poor conductor. This condition is defined as "intrinsic" semiconduction. At absolute zero an intrinsic semiconductor is essentially an insulator. At finite temperatures, however, enough electrons are thermally excited so as to become free electrons and allow for some electrical conduction.

However, if a tiny amount of a certain impurity is introduced into such a structure, important changes occur. Two elements may be cited which are in neighboring groups in the periodic sequence — aluminum (element 13, with three valence electrons) and arsenic (element 33, with five valence electrons). Each of these has very close to the same atomic diameter as germanium, which is one of the requirements for a "stranger" atom before it can replace a "host" in its normal position in the space lattice.

Figure 3 indicates what is thought to happen when an atom of arsenic replaces an atom of germanium within the crystal. Four of the five valence electrons carried by the arsenic atom are used to link-up with the four surrounding germanium atoms, but since the excess electron cannot enter any of the completed bonds, it is permitted to wander through the lattice. An electric field will cause it to drift in the direction of the applied force and to carry a current. This type of conductivity is known as the "n-type conductivity" and the impurity element that carries the current is known as a "donor".

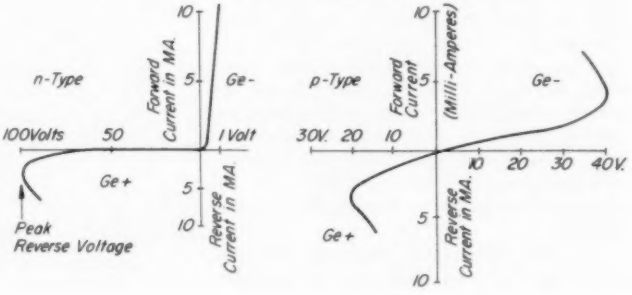
On the other hand, Fig. 4 represents what happens when an element in the third group of the periodic table like aluminum is added. Aluminum is an atom with three valence electrons. When substituted for a germanium atom in a lattice, this type of impurity atom is incapable of completing the balanced system of valence bonds surrounding the normal germanium atoms on all sides. Thus an electron deficiency or a "hole" occurs in the lattice. A hole in any one bond of the impurity atom apparently can be filled by an electron from an adjacent bond. When this happens, the hole wanders away to the bond which just gave up one of its electrons. Under the influence of an electric field the holes will drift in a systematic way and thus contribute to the flow of current. This type of conductivity is known as the "p-type" and the impurity element is known as an "acceptor". (It might be anticipated that p-type conductivity could be produced by spatial holes or dislocations in a germanium crystal of high purity — and this effect has indeed been demonstrated experimentally.)

Relationship between imposed voltage and current passing is shown in the typical patterns of Fig. 5. The theory of surplus electrons and "holes" does not explain readily the fact that both n-type and p-type germanium passes current more readily in one direction than in another. For example, Fig. 5 shows that 1 volt will pass a forward current of 10 milliamperes but practically none in the opposite direction. It is such circumstances which make semiconductors so extremely useful for rectifying devices which replace some of the common vacuum tubes. One of the most common is the diode shown in Fig. 6 and 7 in which a metallic whisker is brought to the surface of a germanium pellet in much the same manner as the old galena crystal was used by the radio ham. Such construction permits the passage of more current in one direction than the other and therefore gives rectifying action.

Before passing on to the problem of manufacturing germanium crystals it would be well to make a few more remarks about the electrical properties of semiconductors.

Good electrical conductivity is of course a most important desideratum. Elementary physics teaches that the ratio of the electric

Fig. 5 — Typical Rectification Patterns for n-Type and p-Type Germanium Diodes With Tungsten Point Contacts. (After H. C. Theuerer and J. H. Scaff, *Journal of Metals*, January 1951, p. 59)



field within a material to the rate of flow of charge per unit area in the direction of the field is known as the resistivity of the substance and is generally written ρ. Its reciprocal, the conductivity, is written as σ. Either of these parameters can be used to describe the resistance offered by a substance to the flow of current.

The resistivity of a particular sample of germanium can also be used as a measure of the total of the impurities it contains. In general, the greater the impurity the lower will be the resistivity, and the higher the conductivity. Concentrations of some impurities of less than one part per million may be very important in determining the conduction properties of germanium. E. E. Schumacher in the 1950 Institute of Metals Division Lecture stated: "One part of antimony in 100 million of germanium doubles the conductivity."

Fig. 7 — Germanium Diode, 0.20 In. in Diameter and 0.5 In. Long, With Leads 1 In. Long. Shown full size

Another important property of germanium gives rise to the "Hall effect". If a conducting strip is so placed that its major plane is perpendicular to a strong magnetic field and a current passed along that strip, the lines of current flow are distorted sidewise, and a potential difference is developed in this sidewise direction, proportional both to the magnetic field strength and current density. In symbols:

$$\text{Hall Coefficient} = R = \frac{V_y t}{HI} 10^8$$

where V_y is the Hall voltage across the strip, t is the thickness of the conducting strip, H is the strength of the magnetic field, I is the current passing along the strip.

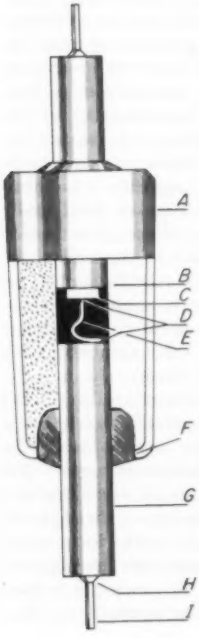


Fig. 6 — An Enlarged Cut-Away Showing Construction of Diode
A. Mineral-Filled Plastic Case
B. Solder
C. Germanium Pellet
D. Welds
E. 3-Mil Whisker, 90-10 Pt-Ru
F. Thermosetting Cement
G. Nickel Pin
H. Weld
I. Leaded Copper-Clad Wire

The Hall effect is important in determining the number of conduction carriers. As R increases, the number of necessary carriers decreases, and vice versa.

The third important property of germanium is electronic mobility, a measure of the ease with which electrons can move about under the influence of an electric field. A much simplified statement is this:

If an electric field E exists, there is a force on a particle-carrying charge e that is given by the equation $F = eE$. If there were no other particles in its path, it would assume a uniform acceleration while acted upon by this force. However, at collisions, these obstructing particles deflect it and share its energy so that in general a velocity is reached which is proportional to the electric field. The constant of proportionality between this velocity and the field is the mobility denoted by the symbol μ. Solid state theory predicts that mobility, resistivity and Hall coefficient are related according to the equation $\mu = R/\rho$.

PROCESSING OF GERMANIUM BILLETS

At the outset of this article the metallurgical story of germanium was outlined up to the production of powder metal, and the story was then diverted to its crystallinity and remarkable electrical properties. Let us now come back to the production of large crystals.

The actual processing of germanium billets may be divided into two major operations:

1. Reduction of GeO_2 to metal and melting it.
2. Progressive crystallization of the germanium melt.

The first step in the reduction of germanium dioxide is the loading of graphite boats with GeO_2. The graphite used in making the boats is of the highest purity obtainable, as is the germanium dioxide. Graphite is used because it contains little or nothing which can contaminate the ger-

manium. Quartz would also be a suitable container. The boat or boats are then covered with a piece of graphite or quartz and placed in a stainless steel can.

The loaded can is placed in the entrance vestibule of a hydrogen furnace (Fig. 1), observing the usual precautions taken in operating such a furnace. After purging or flushing the can with pure dry hydrogen for approximately 10 min., the furnace is brought to a temperature of 650° C. (1200° F.) and the can is pushed into the heating chamber. The GeO_2 is reduced at this temperature by contact with a continuously passing flow of dry hydrogen. It takes about 2½ hr. to reduce a charge of about 70 g. of GeO_2.

During the next half hour the temperature is raised to 1050° C. (1925° F.) to complete the reduction. The germanium is now liquid. The boat is then pushed from the heating chamber and quickly cooled in the water-jacketed exit chamber. Reduction by this method results in a 48-g. germanium melt from 72 g. of germanium dioxide.

After the germanium melts are removed from the can, they are ready for progressive crystallization. The essential feature of this process is a specially designed electric furnace which melts the metal under helium or argon atmosphere, and by cooling at a definite rate permits controlled directional cooling of the charge. The charge comprises a number of germanium melts. Figure 8 shows a workman removing the graphite boat containing a germanium billet from the progressive recrystallization furnace.

Billets are checked for purity by measuring the Hall coefficient at five different locations. The Hall coefficient varies from high at the pure end to low at the impure end. Billets which do not meet minimum requirements may be purified for use in high back-voltage diodes by recrystallization.

Germanium billets produced in this way vary in rectification characteristics depending on the time of solidification. In discussing such characteristics, billets have to be classified as "pure" germanium or "doped" germanium. The former is a billet having a high Hall coefficient, while the latter represents a billet to which a definite amount of a specific impurity has been added, and has a low Hall coefficient. "Pure" germanium is the best material for high back-voltage rectifiers, while doped germanium is used in rectifiers designed to operate at frequencies above 100 megacycles.

A satisfactory "pure" germanium billet consists entirely of n-type germanium, and has a low resistance at one end and high resistance at the other. The variation of resistance from end to end can be explained by considering that the first material to solidify and that having the lowest concentration of impurities is at one end. As solidification progresses, the impurity concentration increases until finally the greatest concentration is had at the other end, which solidifies last. This is quite analogous to the segregation of sulphur near the sinkhead of a steel ingot.

Occasionally a billet is produced which has a p-type portion while the remainder is n-type. Not unusual is a billet which is p-type throughout. These variations occur although the same dioxide and processing are used during production. Here

Fig. 8 — Workman Removing Recrystallized Germanium Billet From Processing Furnace

again an explanation can be found in the cooling cycle. Probably the cooling conditions are such that an excess of active acceptor carriers is present in the first material to solidify and the material is p-type. Due to differences in segregation rates, as freezing progresses, the donor concentration rapidly overtakes the active acceptor concentration, and an inversion to n-type germanium occurs. If not, the billet will be completely p-type germanium.

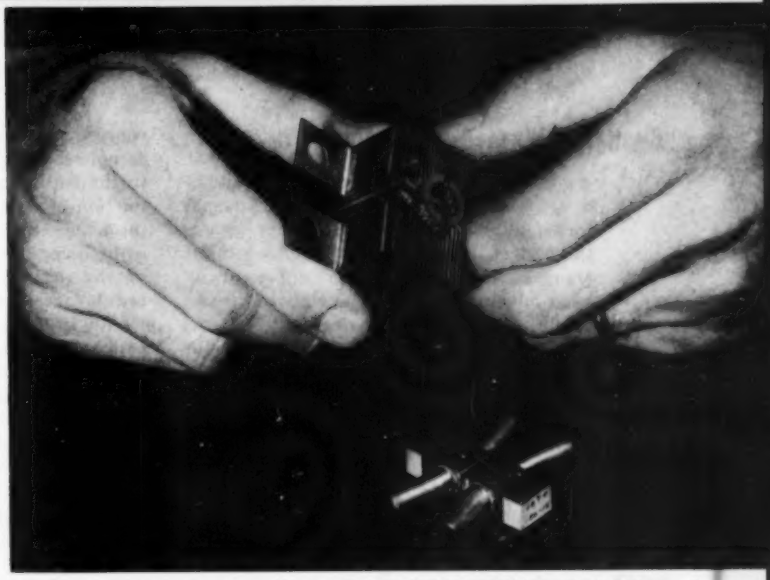


Fig. 9 — Germanium Rectifiers, Air-Cooled (in Hands) and Water-Cooled Type. Instead of point-point contacts used for radio and radar, these use an effective contact area of 1 sq.cm., can rectify 1 kw. of power, and will pass several hundred amperes of current with only 0.75-volt drop of potential. (From *General Electric Review*)

Doping of Germanium — The known donors for germanium are arsenic, antimony, phosphorus and bismuth. The presence of any one of these in the germanium billet will affect its electrical characteristics. Even the purest GeO_2 obtainable will possess impurities which are passed on to the germanium billet. Should the impurity be arsenic and in excess of about 0.001%, the high back-voltage characteristics of the billet are seriously impaired. Experiments have indicated, however, that a small residual amount of donor impurity is necessary for n-type rectification.

If germanium diodes are to be used at frequencies above 100 megacycles, it is necessary to dope billets intentionally. If the degree of doping is correct the result is an extremely n-type billet. Diodes made from such an ingot will possess very low forward and back resistance and very good rectification efficiency. By proper adjustment of very minor amounts of donors and acceptors (plus correct subsequent processing) one can "tailor" a rectifier to fit desired electrical specifications.

Among the methods used for doping are the direct addition of the particular impurity, such as arsenic, or the addition of small amounts of previously heavily doped germanium before the recrystallization cycle.

At times it may be desired to add an "acceptor" rather than a "donor". Such a case would arise if it were necessary to reduce the strength of n-type material in a billet. Aluminum is commonly used for this.

Heat Treatment — It is possible to modify reversibly the conductivity of germanium and also to convert germanium from n-type to p-type by heat treatment. This conversion occurs at temperatures above 550° C. (1025° F.) the more rapidly as the temperature is higher. For example, a billet of normal size, originally n-type, may be completely changed to p-type by heating 24 hr. at 800° C. (1475° F.) and air cooling. The more impure the germanium the higher is the temperature required to convert the material. The thermal conversion of germanium from n-type to p-type is reversible — that is to say, an n-type billet by virtue of heat treatment will revert to p-type by reheating at 500° C. (930° F.) for 24 hr., and may be reverted to n-type by a second reheating at 500° C. for 24 hr.

Heat treatment theories are highly conjectural at present. The balance between donor and acceptor impurities contained in a single crystal is undoubtedly influenced by subjecting it to various temperatures, but the mechanism responsible has not been definitely established.

Germanium metallurgy is still closer to an art than a science. Explanations are being found for many of the properties of germanium, and at the same time more precise ways of varying its characteristics are coming to light. It is definitely established as a powerful tool in the electronics industry and its use will increase in the future.

Steel "Quality" — What It Is and How to Get It*

By Harry W. McQuaid, Consultant, Cleveland

IN MY TIME I have engaged in many discussions about what you get when you pay for "quality" in alloy steel and what governs the cost of attaining this mysterious thing. Many have been the heated arguments of what advantage, if any, the electric furnace has in producing quality steels as compared to the openhearth, and the acid versus the basic furnace, and of other details of mill practice. The entire subject is so large that it will be necessary to confine attention at this time to an aspect I regard as most important — furnace practice which will produce steel with dispersed particles of manganese sulphide rather than thin (even submicroscopic) films of iron sulphide.

Many of our esteemed metallurgists firmly believe that the only way to achieve this mysterious thing called quality in steel is to take an hour or two more for the heat and to avoid any semblance of fast working. As a matter of fact, under certain conditions fast melting and finishing of a heat of steel may be what is most needed to produce quality of the highest order. I have seen 3-hr., 40-ton heats of electric furnace S.A.E. 52100 ball bearing steel which were of the very highest quality, while 7-hr. or 8-hr. heats were the reverse. (In this case quality was indicated by the microscopic cleanliness, type and distribution of inclusions, macro-etch test, and all the other tests for chemistry, hardenability, carbide type and dendritic formation. Surface soundness was unusually good also.)

It is interesting in reading the literature concerning the melting of quality alloy steel to note the stress which is placed on *action* in the bath — either incident to the ore reduction of a high-carbon charge, or due to mechanical stirring. The stress on mechanical stirring has resulted in the development of electrical induction attachments to the arc furnace which will cause continuous motion in the bath. Necessity for removing hydrogen is also emphasized because of its supposed connection with flaking and other troubles. I grant that hydrogen is a bad actor in solid steel and that its presence in the melting furnace should be minimized by charging only dry (or dried) solids, but apparently all that is needed to eliminate the adverse effect of hydrogen is action in the bath up to the time that the chemistry and temperature are right for tapping; when this is all accomplished the heat should be tapped without delay.

Note that I have just said "when the temperature is right". One of the most important contributions to quality control in steel melting was the development of a good immersion pyrometer. When properly used, this controls temperatures far more exactly than any other method previously used. With a good immersion pyrometer the really advanced steel melter has found that 25° F. is a large factor in mold life, inclusion count and etch test results. Without it, in my opinion, the control of quality is still very uncertain and hardly worthy of the name.

Globular Sulphides — I think there would be small argument with the statement that the acme of quality has been steel from the small Swedish acid openhearth, using selected scrap and selected fuels, and deoxidized with manganese and silicon; very low sulphur and phosphorus were combined in steel which had unusual cleanliness and ductility and with little or no evidence of banding. This body of experience generally reinforces my beliefs that quality in alloy constructional steels is based on sulphide types and temperature control, more than any of the other factors in steelmaking.

When sulphides are precipitated as relatively large globules, far apart, as in steels deoxidized with manganese and silicon, they have the minimum effect for a given quality of inclusions. The combination of iron, manganese, oxygen and sulphur to give this type of sulphide requires a certain minimum percentage of iron oxide in the molten steel bath, and also more than a minimum ratio

*The first part of a talk given before Detroit Chapter's "Old-Timers' Night", May 12, 1952, entitled "Economics of the Selection of Alloy Constructional Steels". The concluding installment will appear in September.

of manganese to sulphur. Under such conditions the sulphides exist as a combination of iron sulphide, manganese oxide, and manganese sulphide.

This very important basic fact seems to have been overlooked in published discussions. With enough iron oxide and manganese in the molten steel to form the iron-manganese-oxide-sulphide inclusions (which separate as large globules, Fig. 1) the sulphur content can be as high as 0.30% without causing hot shortness, bad surface or difficulties in heat treatment. However, when aluminum or some other strong deoxidizer is used in an amount which will reduce the iron oxide in the bath to below the minimum level, some of the sulphides form as free iron sulphide and precipitate as part of a eutectic in which they constitute a nearly continuous chain or film network around the primary grains, Fig. 2. This has a very harmful effect on ductility, both in the hot rolled and heat treated product. In rolling it is elongated in the direction of hot working and causes a banded structure; it has little effect on the longitudinal properties but a very important adverse effect on the transverse properties. Its effect is also noticeable in the as-cast condition.

As hinted above, there is apparently a combination of manganese oxide, manganese sulphide and iron sulphide which in the right proportions forms an insoluble compound in the steel existing as relatively large globules which are far apart. It should be the objective of the steelmaker to have *all* the sulphur in a given heat of quality steel in a compound such as this and to avoid the formation of intergranular film-type sulphides. This would usually mean a manganese-silicon killed steel with a high enough manganese-sulphur ratio to insure the proper proportion of manganese sulphide, and enough iron oxide in the bath at tap to insure the proper proportion of manganese oxide in the insoluble compound. Over-oxidation, with excess of iron oxide, means too much manganese oxide, too little manganese sulphide, and too much iron sulphide; under-oxidation with strong deoxidizers like aluminum apparently results in too little manganese oxide in the compound and too much iron sulphide. In either case the film type of sulphide will be formed and the steel will not be of good quality unless the sulphur is *very* low.

Fig. 1 — Globular Type of Inclusions of Iron-Manganese Sulphide. 500 ×

Fig. 2 — Iron-Manganese Sulphide Inclusions of Boundary-Film Type. 500 ×

It seems to me that a quantitative determination of the relationships between manganese and iron oxides and sulphides at steelmaking and at solidification temperatures would be the very best guide to practice for "quality" steelmakers. Sulphide types and methods of distribution are of importance to heat treatment as well as to transverse physical properties in rolled or forged sections. A whole evening could be spent in discussing the effect of the fundamental sulphide type on the solubility of iron carbide in gamma iron and the first formation of ferrite in as-quenched martensitic structures, and its part in causing low transverse impact values in heat treated parts. However, this Detroit group would be more interested, I believe, in pursuing the problem of steelmaking practice for quality steel, especially steels for carburized parts.

"Normality" Versus "Quality" — In the plain carbon grades of machine steels, it has been known for years that restricted or controlled deoxidation practice was necessary to produce quality carburizing steels, since the sulphide type in this grade of steel is indicated very clearly by what is known as the "normality". In the alloy type of steels the fight is between the use of aluminum (to produce fine grain) and the presence of sulphur as free iron sulphide (which causes "abnormality" and low transverse ductility).

Manganese in Aluminum-Killed Steel

One answer is to produce steels with very low sulphur with the usual manganese. In such steels aluminum deoxidation has a minimum effect on the formation of a film type of intergranular sulphide inclusion.

If this is the method used by the steelmaker for the best quality, the sulphur should be below 0.010% and the manganese above 0.50% if he uses aluminum to meet the specifications for fine grain. As the sulphur increases above 0.010%, the manganese should be increased to correspond. It was for this reason that when the S.A.E. 4340 (1.75% Ni, 0.80% Cr, 0.25% Mo) was developed from the old nickel-chromium 3240, the manganese was increased from 0.30 to 0.60% to the present 0.60 to 0.80% range. (One of the defects of the early nickel steel analyses was that the manganese was too low for the higher sulphur in the usual openhearth alloy heat.) Manganese by itself is not the only answer, but it is most helpful in improving the transverse properties of aluminum-killed alloy steel of standard sulphur content. In an aluminum-killed fine-grained steel made to the 0.015% max. sulphur specification, it is very beneficial to have the manganese above 0.50%; in aluminum-killed steel with sulphur close to 0.040%, manganese should be close to 1.00%.

Now if you agree that "high-quality" constructional steels need either very low sulphur or some deoxidizer less powerful than aluminum, it follows that preferred steelmaking practice starts with a charge low in sulphur, and may end with an addition of vanadium for grain size control. Deoxidation based on vanadium, manganese and silicon combinations does not deoxidize the bath to the point where the eutectic film type of sulphide inclusion is formed. The use of vanadium for grain size control is more expensive than aluminum and this extra cost may not be warranted, depending on how important the "quality" is in the processing and performance of the part to be made from the steel. In deciding on the quality specification the metallurgist should make sure that he is not buying something he cannot use. If the product will perform satisfactorily after it is processed in the usual manner it is really not very sensible to spend money for extra clean steel, extra sound steel, or steel with anything more than the minimum analysis of alloying elements. These considerations will be expounded at some length in the second part of this talk. I will only pause long enough here to point out that while the use of aluminum is desirable to meet certain specifications for fine grain size, in the presence of the usual sulphur content it affects adversely the tool life and surface, and causes banding and lower transverse properties. If the decrease in distortion and better-looking fractures warrant its use, then there should be little time or money spent to meet severe cleanliness and other so-called quality tests. I repeat — the object is to get the steel which, in the finished part, represents good enough performance for the least cost.

Low-sulphur steel is not difficult to make if we have a sulphur-free charge, or can work the heat in a basic electric furnace. However, it is especially difficult to make in the basic openhearth because the hot metal or cold pig used in the charge usually contains considerable sulphur. Elimination of sulphur in the basic electric is relatively simple but does involve some delay in working the heat and hence increases the expense. In the acid openhearth or electric the necessary low sulphur can only be obtained by a special low-sulphur charge — low-sulphur iron only obtainable in limited quantities at an increased cost.

There has been much work done on the removal of sulphur from hot metal in the ladle, as well as from cupola iron in the ladle, by treatment with sodium and calcium (strongly basic) compounds. This has usually been done by injection or mechanically stirring the compounds into the molten metal in the ladle. It is believed that eventually the combination in the electric furnace of induction stirring with the injection of finely dispersed, strongly basic compounds such as calcium carbide will result in the elimination of sulphur to almost any desired degree. Apparently the closer we can approach to free, well-dispersed calcium or sodium in the molten metal, the faster the sulphur can be removed from either the ladle or the electric furnace.

ADVANTAGES OF ELECTRIC MELTING

Under normal conditions the most economical way of producing low-sulphur alloy heats (and hence heats of superior quality) is in the modern basic electric arc furnace. The whole steelmaking picture has changed

during the past ten years, and we find that the greatly increased scrap, freight, labor and fuel costs have resulted in a very marked increase in the raw material and melting costs of openhearth steel, especially in the so-called "cold metal alloy steel shop". The modern top-charged high-powered electric furnace (while it is subject to the same scrap costs) has enjoyed a rather constant fuel or power rate, and the tons per furnace-hour have increased markedly. This increase in production is especially great in the production of alloy or even carbon steel in competition with the openhearth.*

Where the top-charged electric furnace is adequately powered and the production incentive is high enough, the modern large electric furnace can hold its own in competition with the openhearth on practically any grade of steel. This is being demonstrated every day on such products as barbed wire, nails, cotton ties, reinforcing rod and other carbon steel products. It is equally true on openhearth (single slag) types of alloy steel where the electric furnace is a better melting medium than the openhearth because of its more sensitive temperature control, the higher lime-silica ratio in the slags, better alloy and iron recovery from the scrap, and much higher tonnage from equipment that represents a very much lower investment.

It is my firm conviction that the high-powered, modern, top-charged electric furnace will eventually replace the openhearth in the making of all grades of alloy and special carbon steels, not so much because of the improvement and uniformity of product as because of the lower production cost and greatly reduced investment required.

The nonintegrated basic or acid openhearth plant is placed in an almost hopeless economic position because of its dependence on cold pig iron and special scrap. The high cost of fuel, pig iron and scrap and the low production in tons per hour restricts the competitive operation of the all-cold-charge openhearth to the most special geographic conditions or for a very special product.

In the integrated plant the openhearth shop is part of a combination of ore production, coke-making and blast furnace facilities which require many times the investment of the electric arc furnace plant. Due to tonnage requirements and scrap limitations, the fully integrated steel plant is a necessity in the United States, and the electric furnace working on cold scrap is necessarily limited in its tonnage possibilities. This does not mean that the electric furnace will not replace the openhearth as a method for processing hot metal plus scrap. In fact, this is a distinct possibility, especially if the labor unions get their overtime wishes for Saturday and Sunday operation and thus force a five-day week in the melt shop.

Just because a steel plant has electric arc melting furnaces is no assurance that they compete favorably with openhearths. Many of the largest electric furnaces installed in the past ten years were obsolete when they were installed. This is especially true in the larger mills that insisted on furnaces machine-charged through side doors and of relatively low power. To compete, the electric furnace must be top-charged, have rotary controls, high voltage and power input and an operating crew with a high tonnage incentive and plenty of experience. With this combination, as we find it in the plants of many of the smaller producers, the electric furnace stands out as both a high-quality producer and an economical producer of alloy steel.

Thus we have in the modern, up-to-date electric melting department, where production pressure is high, a constant tendency toward a stable and perhaps a lower cost of production. As long as the present stability of power and electrode cost is maintained and an intelligent effort is always made to produce the necessary quality required at the very maximum tons per average hour, the large, properly designed and powered electric furnace can convert metal into satisfactory ingots in competition with any modern openhearth.

This means, of course, that the electric furnace melter must produce finished steel in the ladle of a quality good enough to compare more than favorably with the competitive openhearth. This requires the fastest single-slag practice in combination with accurate temperatures in the bath and the required deoxidation (and reduction) control. The primary function of the second slag is to reduce sulphur to some desired low limit and to control exactly the degree of deoxida-

*Editor's Footnote — Mr. McQuaid discussed the relative costs of electric and openhearth steels at the American Iron and Steel Engineers' annual meeting last fall. See p. 120 for an abstract of this paper.

The Charge Material

tion of the steel as it goes into the ladle; consequently, when a charge material can be obtained which automatically melts down with the sulphur well below the desired final limits, it is not necessary to slag off electric furnace heats and put on the bath a second, very high-lime slag low in iron oxide. That this is true is demonstrated continually by steel made in the acid openhearth in Sweden, at Roebling's in Trenton, N. J., and other special product melt shops. The well-made Swedish acid openhearth, special-quality carbon toolsteels, bearing steels, and spring steels are full evidence that with a high enough grade of charge the openhearth can produce quality equal to the very best required. My own personal experience would indicate that single slag or special "white" slag practice in a basic electric furnace will produce quality superior to that of any other method of steelmaking.

This sums up to the fact that, with proper charge material that is not unduly expensive, the best quality possible in steel can be produced with an electric furnace melting practice at a maximum rate and low cost.

HARRY W. MCQUAID

His selection to talk at the Detroit Chapter's "Old-Timers' Night" was particularly appropriate. Member of the Chapter for almost 30 years, at one time its chairman, he has been a heat treating foreman, an electric furnace melter, for years a steel-mill metallurgist, a metallurgist in the plant of a large automotive parts producer, and an active member of the Steel Division of the War Production Board during World War II. In these capacities he has visited nearly every major steel processing plant in this country and Canada and has become familiar with the process of converting ore to finished part — production, processing, machining, heat treating, finishing and performance. This includes, especially in the sales and service fields, many details not found in textbooks nor discussed (openly) in technical meetings.

DIRECT REDUCED IRON AS CHARGE MATERIAL

You might say that low-sulphur charge material (iron or scrap) is expensive and probably getting more so, and on this rock the entire argument will split. It is my opinion that much of this desirable raw material of the future will be produced as a byproduct of the manufacture of carbon black from natural gas. The pure hydrogen released in this process is excellent for the economical reduction of magnetite or other high-grade iron ore concentrates. Hydrogen reduces briquetted iron oxide at only 1100° F. to iron in a form which is simple indeed to charge for melting into a steel product of a quality hard to approach by any other method. With the present cost of magnetite concentrates and with the necessary natural gas available, the electric furnace charge material so produced will compare very favorably with any other conventional source of a ferrous charge.

Don't expect these changes to hit customers in Detroit overnight but they are being considered very carefully by at least one of the more forward-looking alloy steel producers. Developments move much more slowly in the steel industry than they do in the automotive industry, with its constant pressure for product change. Part of this slowness to develop as an industry is due to the high cost of any new equipment involved and the difficulty in providing for obsolescence in the present tax laws.

Furthermore, during periods of high demand such as the present, every piece of equipment in the steel industry, no matter how costly to operate, is going strong. Even hand mills built 50 years ago are rolling sheet and have paid for themselves a second time in the profits made in 1950 and 1951. Some of our largest steel producers are operating bar and rod mills which were also installed 50 years ago. On the other hand, some really modern, high-tonnage mills have been

(Continued on p. 164)

Isothermal Heat Treatment of Meehanite Metal

By C. R. Austin, Assistant to President, Meehanite Metal Corp., New Rochelle, N. Y.

TECHNICAL literature available on the S-curve characteristics of plain carbon and alloy steels has been accumulating in considerable quantity during the past two decades, due to the recognition of the importance of a knowledge of these facts to metals engineers. There are relatively few instances where modern steels can offer full economic value unless they have been subjected to some form of heat treatment.

The importance of heat treatment in developing superior properties in high-tensile iron castings is also being generally accepted. It assures an improvement in tensile strength, but particularly in yield strength and toughness, as well as increases hardness against wear and general surface breakdown under conditions where high compression stresses prevail.

A knowledge of the S-curve characteristics of these irons permits a rationalization of heat treat procedures in stress-relief annealing, hardening by the conventional quench-and-draw or by martempering, and interrupted quench treatments in which both temperature of the quenching bath and time of holding play a very important role. The successful application and utilization of S-curve data for iron castings is more involved than similar data for steels for the following reasons:

1. The entire structure of a steel reacts to structural control and modification by heat treatment.

2. Only the matrix structures of iron castings react to these treatments. There is essentially no change in the graphite structure or in the effect of the graphite structure on the physical properties.

RATIONALE OF TREATMENT

When a steel is heated above the thermal critical range, the entire structure is changed to a simple solid solution (austenite). On similarly heating an iron casting, the matrix structure alone is changed to austenite; however, the amount, shape, size and distribution of the graphite are essentially fixed as soon as the casting has solidified in the mold. Thus, an iron casting exhibiting a poor or uncontrolled graphitic structure has inferior properties in the cast condition, and little can be done by any form of heat treatment to improve these properties appreciably. The initial low strength and impact properties of such irons persist after any heat treatment. Accordingly, it is sound economy to heat treat only those iron castings wherein assurance can be had that the graphite characteristics are controlled to promote definite engineering specifications in the cast condition.

For this reason it should be clear why the data submitted in this paper relate specifically to castings manufactured by the "Meehanite" method, which involves a two-step process. First, the charge to be melted is accurately computed to a predetermined liquid composition; then the melt is subjected to a suitable treatment to produce a correct constitution (microstructure) in relation to the casting section to be poured. Such procedures have been found to result in a high degree of uniformity throughout the section, which meets the specifications irrespective of casting dimensions.

To establish the S-curve of such an engineering iron we determined the beginning and end of isothermal transformation of a type "GA Meehanite" casting (50,000-psi. minimum tensile strength, as cast) and the effect of varying the austenitization temperature on the rate of isothermal transformation. Then we studied the effect of selected isothermal treatments on the tensile properties.

The metal investigated was cast in the form of 1.2-in. arbitration bars. The chemical analysis was 3.10% carbon, 1.48% silicon and 0.99% manganese. The principal physical properties, as cast, were: Tensile strength, 52,000 psi.; transverse strength, 4000 lb.; transverse deflection, 0.330 in.; and Brinell hardness, 235.

To study the effect of prior austenitizing temperature, holding temperatures of 1560 and 1785° F. were selected. The rates of isothermal decomposition were determined

Derivation of S-Curves

with a dilatometer at various subcritical temperatures ranging from 600 to 1040° F., and supplementary data on time for start and finish of isothermal transformation were determined metallographically.

From the results of this study, selected heat treatments were recommended for the investigation on the effects of interrupted quenching treatments in terms of both the Brinell hardness and the tensile strength of the heat treated irons.

Jominy end-quench data obtained after austenitizing at 1560 and 1785° F. show the effect of maximum temperature of heating on the hardenability characteristics of this type of iron.

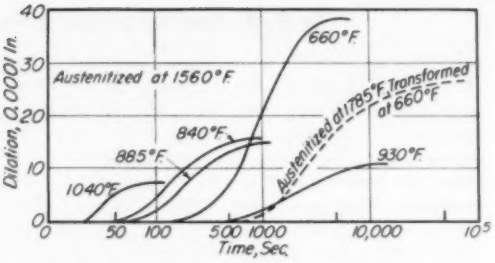


Fig. 1 — Dilatation Curves Showing Beginning and End of Transformation of "GA Meehanite", Austenitized at 1560° F., and Transformed Isothermally at Various Subcritical Temperatures. Note the much more sluggish transformation when austenitization temperature is raised

EQUIPMENT AND PROCEDURE

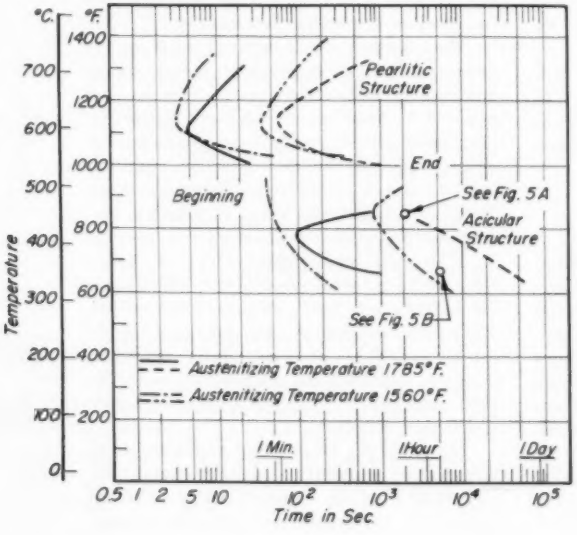
Small specimens (0.04 in. thick) were austenitized in a tube furnace with purified nitrogen atmosphere. The specimens were then quickly placed in a dilatometer and lowered into a lead bath held at the desired isothermal transformation temperature.

Small metallographic specimens were similarly quenched into the molten lead bath, held for the specified time, withdrawn and quickly quenched in water. Specimens remained for various times at each of the constant treatment temperatures. Metallographic examination provided an index of the progress of transformation from beginning to end. Any austenite remaining in the hot sample transformed to martensite on water quenching. Good agreement was obtained between the indices of beginning and end of transformation as obtained by dilatometer and the microscope.

Results are most conveniently reported in the form of curves. Figure 1 shows the type of reaction curves obtained from dilatometric or length-change test pieces isothermally transformed at the temperatures indicated on each curve. It may be noted that some considerable period persists before austenite starts to transform. (This was true of all the curves.) Raising the austenitization temperature materially increases the incubation period of these irons, as is shown by the different location of the transformation-time curves for 660° F., one after austenitization at 1560° F. (full line) and one after austenitization at 1785° F. (dotted line).

Several curves for progress of isothermal transformation at various temperatures after austenitization at 1560° F. are shown in Fig. 1. The S-curve can be immediately derived from these. Two rudimentary S-curves are reproduced after the prior austenitization at 1560 and 1785° F. (Fig. 2). Comparison of these S-curves demonstrates the

Fig. 2 — S-Curves of GA Meehanite (3.10% C, 0.90% Combined C, 1.48% Si, 0.99% Mn) Austenitized at 1785 and 1560° F.



marked increase in stability of the austenite resulting from raising the austenitization temperature.

The effect of austenitization temperature on austenite stability and its relation to austenite grain size is well recognized in steel technology, but little information is available on austenite grain size in irons because of the difficulty in defining it in these materials.

COMPARISON WITH SPRING STEELS

It is of particular interest, however, to compare our results on type GA Meehanite with those available in the literature on high-silicon steels. The chemical analysis most closely approximating that of our type GA metal is A.I.S.I. 9261 with 0.62% C, 2.00% Si and 0.95% Mn as compared with 0.90% (approximate) combined carbon, 1.48% Si and 0.99% Mn for the Meehanite casting. The S-curve for the steel, as given on p. 87 of U. S. Steel Co.'s "Atlas of Isothermal Transformation Diagrams", 1951 Edition, is reproduced in Fig. 3. This steel was austenitized at 1600° F. to a grain size of 6 to 7.

When comparing Fig. 2 with Fig. 3 it may be noted that:

1. The pearlite transformation takes place between 1000 and 1300° F. in the cast metal, about the same as in the spring steel, although the "nose" of the curve is at a slightly shorter time.

2. Transformation to the acicular or interrupted quench structure occurs (in the iron) only within the temperature range between 600 to about 900° F.

3. Between 900 and 1000° F. the austenite in the cast metal is so stable that long holding fails to transform the austenite. Accordingly, these irons transform completely to martensite on air cooling after removal from a salt bath held between 900 and 1000° F.

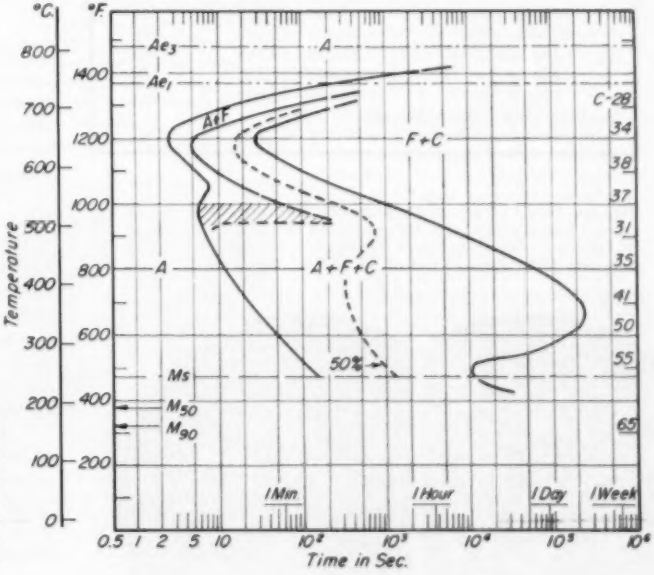


Fig. 3 — S-Curve (Isothermal Transformation Diagram) of A.I.S.I. 9261 Spring Steel (0.62% C, 2.00% Si, 0.95% Mn, 0.15% Cr) Austenitized at 1600° F. Hardness noted on right edge represents samples completely transformed at the temperature noted. A = Austenite; F = Ferrite; C = Carbide

Similarity With Spring Steel

4. This temperature range also is the locus of an anomaly in the diagram (Fig. 3) for A.I.S.I. 9261, as shown by the hatched area and the dotted line which poorly defines the austenite-plus-ferrite region from the conditions where carbide is an additional constituent. (Comparisons of the S-curves of the steel and the iron should not lead to many definite conclusions, since the steel contains a small amount of chromium added to prevent graphitization of the carbide, and the matrix of the iron contains approximately eutectoid carbon. However, there is undoubtedly a close family resemblance between Fig. 2 and 3.)

Jominy Hardenability — As may be anticipated, the difference in the S-curve characteristics with increase in austenitization temperature is reflected in Jominy hardenability (Fig. 4). Lower surface hardness with higher quenching temperature is undoubtedly associated with retained austenite.

Microstructure — Figures 5A and 5B illustrate the microstructural characteristics of metal transformed at 840 and 660° F., respectively. Note the finer acicular structure obtained at 660° F.

Effect of Isothermal Treatment on Hardness and Strength — To study mechanical properties of this iron after isothermal treat-

85,000-Psi. Iron

ment, tensile bars were austenitized at 1560° F. The lower temperature was selected because of the shorter holding times necessary for complete transformation.

The tensile test bars were prepared from the 1.2-in. arbitration bars, and were machined off center. After final heat treatment finished dimensions were obtained by grinding. Brinell hardness was measured on a transverse cut after fracture in the tensile machine. A reduced section was ground to 3½-in. radius in the center of a ½-in. round bar, 5 in. long. The reduced (ground) section was about 2 in. long and the diameter at its center (neck) was 0.200 ± 0.001 in.

All tests were conducted in duplicate and the results, along with details of heat treatment, are given in Table I.

Data for tensile strength show that good agreement was obtained between duplicate tests. Where one of the test results is low it can be reasonably assumed that the higher value provides the truer index of the particular heat treatment. The use of arbitration bars for preparation of tensile test specimens, and the fact that they were machined down to a gage section of 0.2 in., naturally magnifies the effect of any minor or local interdendritic shrinks. The simple arbitration test bar is not fed by a riser, as is mandatory in all castings of this type which are manufactured for the consumer industry.

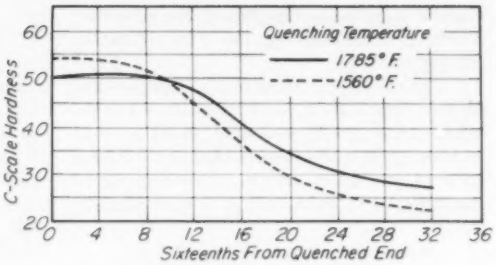


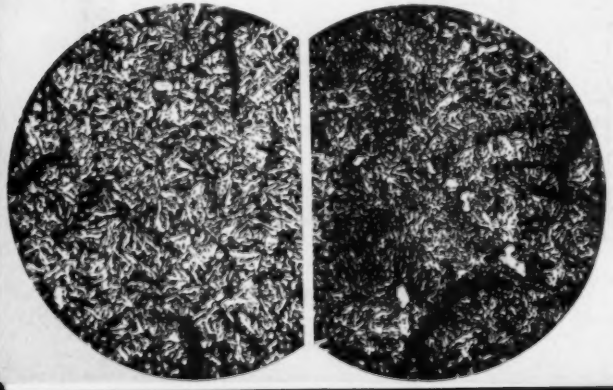
Fig. 4 — Quenching GA Meehanite From Too High a Temperature Retains Enough Austenite to Affect Surface Hardness

It must be emphasized that the prime purpose of the tests was to define the relative difference of the effects of the various heat treatments on tensile strength and Brinell hardness of GA Meehanite castings without introducing any mass effect.

Table I — Strength and Hardness of Heat Treated Samples

Austenitized at 1580° F. and Quenched	Tensile Strength Psi.	Brinell Hardness
5 min. at 1000° F.	67,960 – 68,080	295
10 min. at 900° F.	57,180 – 59,010	265
30 min. at 800° F.	65,450 – 65,200	265
1 hr. at 700° F.	76,200 – 67,040	295
2 hr. at 650° F.	86,970 – 86,230	340
4 hr. at 600° F.	86,250 – 81,500	375
In oil — (Gulf "Super-Quench") then in liquid nitrogen	63,920 – 57,740	600

Fig. 5A (Left) — Acicular Structure Resulting From Complete Transformation at 840° F. Fig. 5B (right) — Somewhat finer needles and harder structure from transformation at 660° F. 500 ×



General Comments

It has been established by these experiments that an increase in austenitization temperature increases the stability of the austenite, and this observation has been confirmed by the Jominy end-quench test (Fig. 4).

The Rockwell values of C-50 to 55 reported on this curve are equivalent to Brinell 500 to 550. Such material is file-hard and comparable to the values obtained with fully hardened toolsteels. At lower isothermal transformation temperature levels the hardness of heat treated Meehanite castings is comparable with that of the 9261 spring steel similarly heat treated.

Maximum tensile strength of over 85,000 psi. was obtained from interrupted quench within the temperature range 600 to 850° F. These values were obtained at approximately 350 Brinell hardness.

Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

High-Chromium, High-Carbon Iron

. . . the Iron That Hardens as it Wears

In many applications involving extreme abrasion, ordinary work-hardening alloys are not suitable. This is because most of these alloys require a definite pounding action for a martensite transformation, and the scouring action of an abrasive is not sufficient for development of high wear resistance. For this reason, high-chromium, high-carbon irons were developed — irons that wear-harden.

Chromium Content of Irons Ranges from 24 to 30 Per Cent

These irons are made in the electric furnace and have the following composition range:

Chromium	26 to 28 per cent
Carbon	2.60 to 2.80 per cent
Manganese	0.50 to 1.25 per cent
Silicon	0.25 to 0.75 per cent
Sulphur	max. 0.05 per cent
Phosphorus	max. 0.05 per cent
Nickel	minimum
Iron	balance

Irons of this composition are readily castable by steel casting techniques.

Development of Greater Wear Resistance by Heat Treatment

Structurally, these irons consist of primary iron-chromium carbides in a matrix of iron-chromium solid solution and secondary iron-chromium carbides. They are hard in the as-cast condition (500 to 550 Brinell), but when they are given an austenitization heat-treatment they develop much higher hardness (about 600 Brinell), and also have greatly improved wear resistance. Austenitization consists of heating these irons to a temperature of about 2012 deg. F. for an hour, then allowing them to cool in air. This heat-treatment promotes the formation of very unstable austenite—austenite that will transform to a harder martensitic end-product even under rubbing or mild impingement action. Austenitization has been found to be far more effective in increasing wear resistance than the promotion of unstable austenite by the addition of ferrite-forming alloying elements.

High-chromium, high-carbon irons can also be annealed to sufficiently low-hardness values for grinding or simple machining. Hardnesses as low as 350 to 450 Brinell can be obtained by heating the castings to temperatures of 1400 to 1450 deg. F. for 12 to 24 hours, then allowing them to cool in air.

Irons Have Wear Resistance Many Times That of Other Alloys

Austenitized high-chromium irons have been known to last as much as 21 times longer than other wear-resistant alloys in applications involving extreme frictional abrasion. These applications include sand-blast nozzles and liners, pantograph contact shoes, grinding disks, pulleys, chute-liner plates, dredge-pump liners, and rollers for crushing various hard materials.

In a recent test, high-chromium iron was compared to special wear-resistant steel castings as the material for hammers in a machine that was used to crush abrasive material. The chrome-iron hammers were found to have almost 7 times the wear resistance of the steel castings.

Fig. 1. After crushing the same amount of abrasive material in a hammer mill, the badly worn steel casting (left) had a weight loss of 37 per cent while the high-chromium iron casting (right) lost only 5.5 per cent.

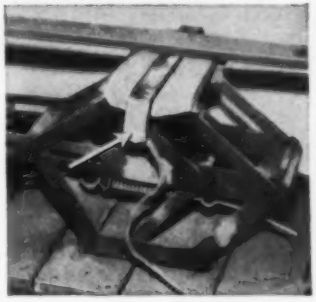


Fig. 2. This chrome-iron pantograph shoe had a service life of about 10 years. A tool steel that was used in similar service wore out in about 3 or 4 months; copper lasted about 24 hours.

When thoroughly backed up with zinc, the iron also has enough shock resistance to be used effectively as crushing hammers and jaw plates for many severe rock-handling jobs.

Metallurgical Service Available

For years, ELECTROMET high-carbon ferrochrome has been used to make chromium additions to abrasion-resistant high-chromium irons. If you should have any questions about either the production or use of these irons, write to the nearest ELECTROMET office. Our metallurgists will be glad to give many valuable suggestions and recommendations on how to make or use this iron most effectively.

Write for a free copy of the ELECTROMET publication, "Abrasion-Resistant High-Chromium Iron." This booklet is a collection of some of the best available information on how to make and to use abrasion-resistant iron castings most efficiently.

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Personal Mention

Gilbert E. Doan

Allison Butts

GILBERT E. DOAN, who has been head of Lehigh University's department of metallurgy since 1939, has been appointed manager of the metallurgical branch, research department, Koppers Co., Inc., Pittsburgh. In his new position, Dr. Doan will work closely with Koppers Metal Products Division, its engineering and construction division and its Freyn Department (Chicago) which design and erect steel plants and their components. He graduated from Lehigh in 1919 and received his Ph.D. degree from the University of Berlin, Germany. Dr. Doan is author of a leading textbook "Principles of Physical Metallurgy" which is now in its third printing and more than a score of his research papers have appeared in national periodicals. For the past 20 years he has at various times been a special consultant for firms such as General Electric, Westinghouse, Bethlehem Steel and Union Carbide and Carbon. He was cited by President Hoover in 1931 for his work in the discovery of radiography by gamma rays; awarded the Lincoln Gold Medal of the American Welding Society for welding research; and has won the Bradley Stoughton Award of the Lehigh Valley Chapter. Last year Dr. Doan was chairman of the education group of conferees to the World Metallurgical Congress in Detroit. He is presently chairman of the National Nominating Committee.

Succeeding Dr. Doan as head of the department of metallurgy at Lehigh is ALLISON BUTTS, professor of electrometallurgy. Prof. Butts came to Lehigh in 1916 from the U. S. Metals Refinery Co. where he served as research chemist for three years. A graduate of Princeton University, he also holds a science degree from Massachusetts Institute of Technology. Long active in technical societies, Prof. Butts has been vice-chairman of the mineral technical division of the American Society of Engineering Education and is a member of the Electrochemical Society and the Institute of Metals of Great Britain. He is co-author with Bradley Stoughton of a text entitled "Engineering Metallurgy", and also wrote "Textbook of Metallurgical Problems". He served as associate editor of *The Mineral Industry* from 1916 to 1927. For many years he served as consulting editor on metallurgical terms for *Webster's New International Dictionary* and as an abstracter for *Chemical Abstracts*. He has also contributed articles on copper and metallurgy for *The Encyclopedia Britannica* and the *American Annual*. At present Prof. Butts is editing material on copper in the American Chemical Society's monograph series.

Sam B. Horwitz has been named president of Midcontinent Tube Service, Inc., Chicago.

B. A. Lindner, formerly a representative of Fairchild Aircraft, Hagerstown, Md., at Willow Run, Mich., is now chief engineer at the Arlington, Texas, plant of General Motors Corp.

Joseph V. Kielb has been appointed production manager of both Newark, N. J., plants of Tenney Engineering, Inc. He will be in charge of all test chamber production, plant personnel, production methods and coordination with engineering and sales.

Gustav Laub has been elected a director of Vanadium Corp. of America. He has been associated with the company for the past 37 years, beginning as secretary to the chairman of the board of the former American Vanadium Company. When that company was purchased by the present Vanadium Corp. of America, Mr. Laub was assigned to take charge of the business affairs of a new division at Primos, Pa. In 1920 he took over the closing of mining operations in the West due to the depression, and a year later transferred to the New York office as assistant secretary. Later he was assistant general manager of sales, and in 1930 was promoted to general manager of sales. He became assistant vice-president in 1937, and vice-president in charge of sales in 1949, a position which he held at the time of his election to director.

F. H. Allison, Jr., has been appointed to the newly created position of assistant vice-president of Blaw-Knox Co., Pittsburgh, in charge of metallurgy and roll sales. Dr. Allison was formerly chief metallurgist at United Engineering and Foundry Co., Pittsburgh.

John O. Paull has been appointed branch industrial manager at Los Angeles for the industrial division of Minneapolis-Honeywell Regulator Co.

Emanuel Gordon has joined the engineering department of Metal Hydrides, Inc., Beverly, Mass., where he will be in charge of special pilot plant operations.

William J. Parsons has been named vice-president in charge of the industrial division, Pacific Scientific Co., Los Angeles. "Bill" was secretary-treasurer of the Los Angeles Chapter for twelve years.

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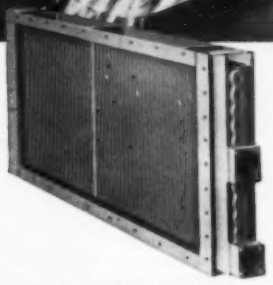

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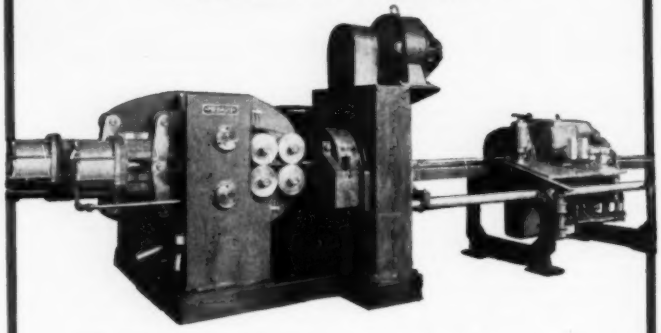

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Personals

Stanley G. Kroto has been appointed sales and engineering representative throughout Ohio for the Alloy Engineering & Casting Co., Champaign, Ill.

H. M. Oshry has been named vice-president and director of the Crawfordsville (Ind.) Foundry Co.

Harold Lee Maxwell, supervisor of mechanical engineering consultants, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., has been nominated to the presidency of American Society for Testing Materials for 1952-53. Dr. Maxwell is currently vice-president of A.S.T.M., a member of the finance committee and chairman of the executive committee. **Norman L. Mochel**, manager of metallurgical engineering at Westinghouse Electric Corp., Philadelphia, has been nominated to the vice-presidency. Mr. Mochel is at present a director of A.S.T.M. and a member of the ordnance advisory committee. **George R. Gohn** and **A. O. Schaefer** have been nominated to the board of directors. Mr. Gohn is supervisor of creep and fatigue laboratories, Bell Telephone Labs., New York, and has served actively on technical committees of A.S.T.M. for many years. Mr. Schaefer, vice-president in charge of engineering and manufacturing, Midvale Co., Nicetown, Philadelphia, is completing two terms as chairman of the A.S.T.M. Philadelphia district. He is a past chairman of the Philadelphia chapter of American Society for Metals and is currently a nominee for national trustee.

Gerald G. Hatch has been appointed director of research and development at the Quebec Iron and Titanium Corp., Montreal, Canada. Dr. Hatch was formerly with the Armour Research Foundation of Illinois Institute of Technology, Chicago.

Pol Duwez has been promoted to the rank of professor of mechanical engineering at California Institute of Technology.

Harold P. Yarian, formerly assistant chief metallurgist of Willys-Overland Motors, Inc., Toledo, Ohio, has been appointed chief metallurgist of Wilson Foundry & Machine Co., Pontiac, Mich., a subsidiary of Willys-Overland Motors.

PHOTOGRAPHY HELPS A COSMOTRON KEEP PROTONS IN LINE

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This monster magnet is built of laminations of ½" steel sheets, 8 feet high, 12 in a 5.7-ton bundle, 288 bundles in all. Each bundle had to be carefully matched to its neighbors to give the utmost overall uniformity of magnetic parameters.

Photography provided a practical solution to the matching problem. The magnetic phenomena of each block were displayed on a cathode-ray oscillograph and photographed with a Kodak 35 camera. Five months and 8,000 oscillograms later (the shutter didn't fail once), a complete set of photographs like those seen here of the characteristics of each block made it possible to determine the position of each one in the magnet ring, to insure the most satisfactory magnetic field.

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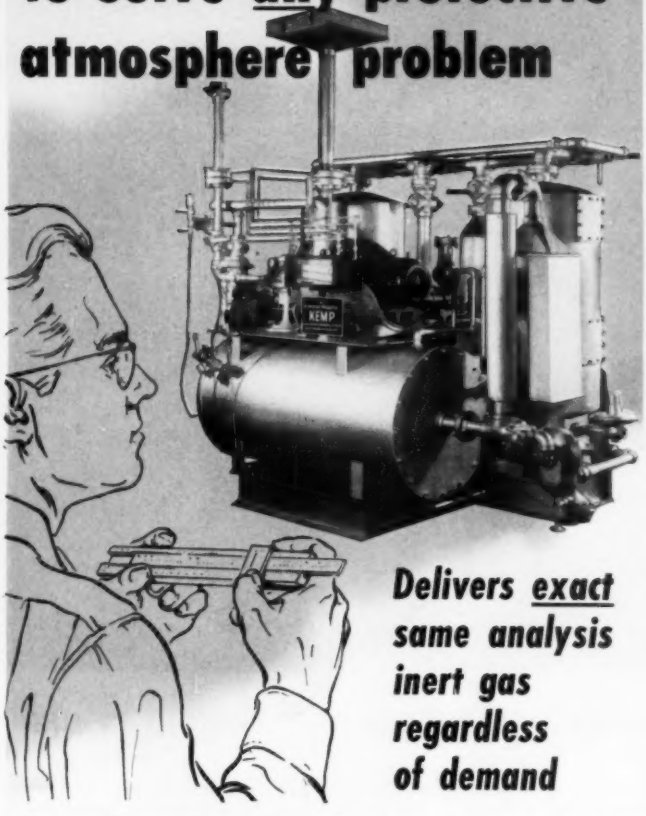

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THE C. M. KEMP MFG. CO.
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Personals

E. M. Kline has been promoted to general manager of the Huntington, W. Va., works of The International Nickel Co., Inc. His former position was that of assistant general manager, a position to which **G. K. Crosby** has been appointed. Mr. Kline has been with International Nickel at the Huntington works since 1923 when he began as assistant chief chemist. He was appointed chief chemist in 1926 and works technical director in 1939, becoming assistant general manager in 1947. Mr. Crosby joined International Nickel in 1936 as a metallurgist and successively became combustion engineer, assistant to the general manager, superintendent of production and general superintendent.

Jacques W. Lourie has been appointed director of foreign sales for Hydropress, Inc., New York. He is a mechanical engineer and has been a leading staff member of Hydropress and its Loewy Rolling Mill Division for over ten years.

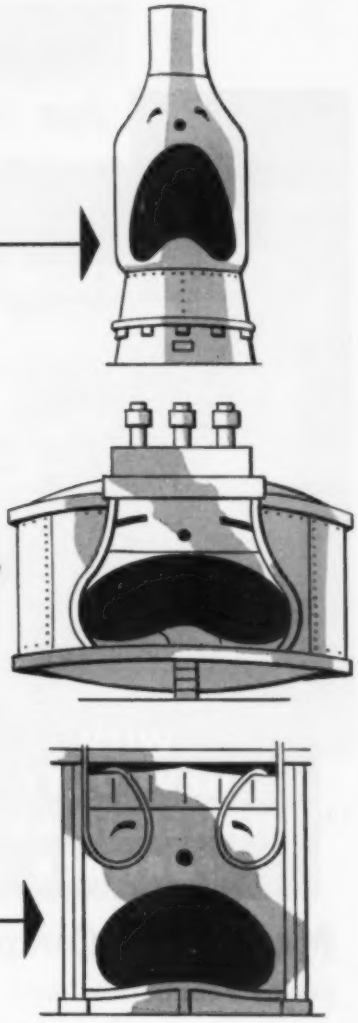
Kenneth I. Johnson has been named an assistant application engineer in Allis-Chalmers processing machinery department at Milwaukee, upon completing the company's graduate training program. Mr. Johnson joined Allis-Chalmers after receiving his metallurgical engineering degree from Michigan College of Mining & Technology.

Norman R. Gilino, U. S. Army Ordnance Corps lieutenant, has been assigned to Redstone Arsenal, Huntsville, Ala., key Ordnance Corps rocket and guided missile installation, as a student in a guided missile course established there.

Gordon J. LeBrasse, formerly superintendent of the research laboratory, Federal-Mogul Corp., Ann Arbor, Mich., has been named acting director of research.

David Rozet has joined Weldwire Co., Philadelphia, as vice-president and director of research. Previously he was employed for more than nine years by Arco Corp., Philadelphia. Since his graduation from the University of Brussels (Belgium) with a D.Sc. degree, Dr. Rozet has been active on both sides of the Atlantic in various phases of research on coatings of arc welding electrodes.

Help feed these hungry mouths!



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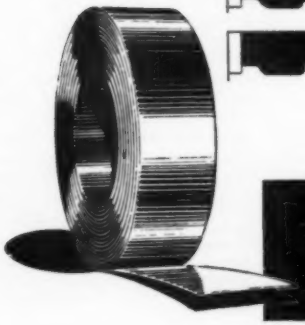

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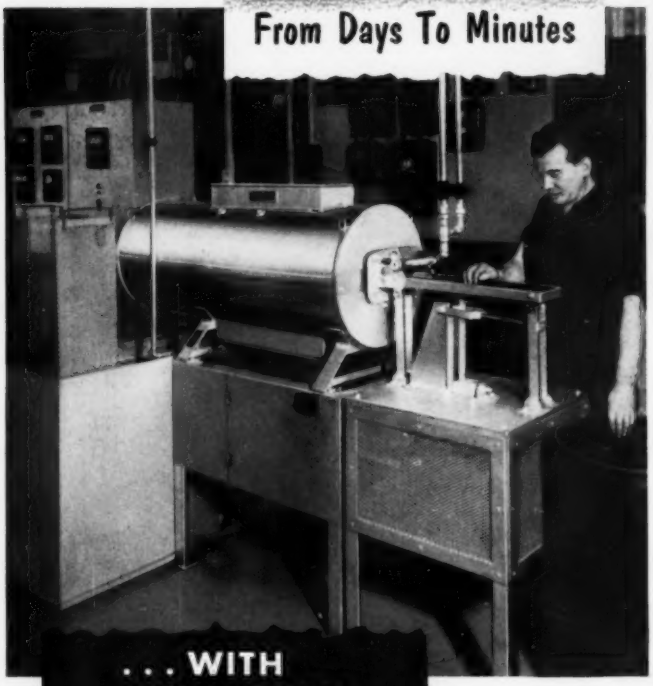

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FURNACE

Master Lock Company

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Now in a Hevi Duty Shaker Hearth Furnace, a similar batch is "bright" hardened in 75 minutes. Each spring receives uniform heat treatment without distortion thus cutting production costs. This furnace has been designed to solve your problem of heat treating small parts.

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Learn more about this modern production tool and the way it can help you.
WRITE FOR BULLETIN HD-850.

HEVI DUTY ELECTRIC COMPANY
MILWAUKEE 1, WISCONSIN
Heat Treating Furnaces . . . Electric Exclusively
Dry Type Transformers *Constant Current Regulators*

Economics of the Small Independent Steel Plant*

ADMITTING that large *modern* open-hearth (including advanced control equipment and getting 60% of its charge as molten pig iron) in a completely integrated steel plant is "the most economical method of producing carbon steel known today", Mr. McQuaid argues the thesis that modern arc furnaces casting billet-sized ingots is a more economical unit when production is 50,000 to 100,000 tons per year, citing the Connors Steel Co. mill at Birmingham, Ala., as an example.

He analyzes steelmaking costs in comparative plants making 300,000 tons per year and finds them about equal. (The electric plant contains two 20-ft. furnaces and would cost $2,675,000; the openhearth plant contains four 150-ton furnaces and costs almost exactly twice as much.) Operating costs based on electric power at 8 mils per kw-hr. are:

	Electric	Openhearth
Power (fuel)	$5.60	$3.30
Labor	1.65	2.00
Repairs, refractories and rebuilding	1.40	2.80
Supervision	1.75	1.80
Miscellaneous	3.10	3.90
Total	$13.50	$13.80

Thus the operating costs of converting cold metal into ingots are the same. However, the electric furnace plant costs only half as much and hence capitol charges are correspondingly less. Furthermore the desirable heavy melting scrap for the openhearth is more costly than the light bushelled scrap the electric furnaces can handle; likewise iron losses to slag are higher in the openhearth.

Under these considerations the electric furnace steel would be notably cheaper than openhearth steel even from such a moderate sized plant, and the cost advantages of electric steel increases as the capacity of the plant decreases. It results that such a mill, capable of producing 50,000 to 100,000 tons of carbon steel in the form of simple shapes (rolled direct from billet-sized ingots and therefore requiring no blooming mill), can efficiently serve manufacturing centers somewhat distant from the large steel plants, and even a large consumer of steel no matter where located.

The above thesis is based on

(Continued on p. 122)

*Abstract from "Comparative Economics of the Electric Furnace and Openhearth", by H. W. McQuaid, *Iron and Steel Engineer*, January 1952.

DETREX

PHOSPHATE COATINGS

Three operations— ALL with ONE LUBRICATION

BLANK AND FIRST DRAW

FIRST REVERSE DRAW

SECOND REVERSE DRAW

EXTRUDITE PROCESS simplifies drawing operations through better lubrication!

The Extrudite Process chemically interlocks the lubricant to the work surface . . . metal-to-metal friction is prevented even during the most severe working conditions. As a result cold forming operations can be speeded up on present equipment, parts are produced with less scrap and many process anneals and chemical treatments are eliminated.

Shown above are cases for hermetically sealed electronics transformers, designed to meet rigid MIL-T-27 Specifications, and being produced by the General Electric Company. Previously, three lubrications were needed and the last one was made with pigmented drawing compound . . . hard to put on due to the contour—requiring a difficult cleaning operation to remove. With the Extrudite Process, only *one* lubrication is used, which is applied on the flat stock. Further, the metal cleaning operation after drawing is greatly simplified. As an added benefit, the drawn parts are protected by Extrudite against rust if stored before the next operation.

If you are now performing cold forming operations—such as drawing of sheet, tube or wire; room temperature extrusions; cold heading—investigate the Extrudite Process. **Detrex Corporation, Box 501, Detroit 32, Michigan.** x-3

Details of the Extrudite Process and its advantages are contained in this informative bulletin. Send for yours today, there is no obligation.

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TECHNICAL TOPICS

Basic Principles of Corrosion

Norman S. Mott
Chief Chemist and Metallurgist

Aqueous corrosion is the electrochemical destruction of a metal by its chemical environment. It may take place in two forms, general over-all corrosion, or localized attack. In this corrosion picture, metals and alloys fall into two groups: those which resist corrosion because of their low position in the electromotive series with respect to hydrogen, and those which resist corrosion because of their ability to build up a condition of surface passivity. This condition of passivity confers on the metal or alloy a degree of nobility, placing it below hydrogen in the electromotive series and therefore making it greatly resistant to acids and other corrosive chemicals.

The stainless steels with their high chromium content represent a class of corrosion resistant materials which rely mainly on this surface condition of passivity for resisting attack.

Unfortunately, these stainless steels do not remain passive under all conditions, and become borderline, i.e., active-passive, or completely active. This depends upon the oxidizing power of the corrosive or upon its depassivating strength if it is of a reducing nature.

Localized corrosive attack may take place on stainless steels in various forms: intergranular, pitting, electrolytic or the concentration cell type of attack. Intergranular corrosion is a form of corrosion which takes place at the grain boundaries of austenitic stainless steels as a result of carbide precipitation at these boundaries due to adverse heating in the range of 900–1600°F. This is a phenomenon associated only with chromium carbide precipitation and may be obviated by using added elements, such as columbium or titanium, which form preferential carbides or by the carbide solution annealing heat treatment consisting of water quenching from 1950–2150°F. It may also be somewhat alleviated thru chemical composition balance by the introduction of 4–10% of ferrite in the austenitic structure. Intergranular corrosion does not take place in the martensitic or ferritic types of stainless steels.

Pitting corrosion is a localized breakdown of the passive surface condition and is caused by segregation of alloy components, carbide precipitation thru improper heat treatment, scale particles or inclusions, local concentration of the corrosive, or by stresses set up by mechanical working. It occurs more frequently in stagnant solutions and is promoted thru the mechanism of the concentration cell type of corrosive action. Certain types of corrosives such as chlorides and other halides have a great tendency to cause pitting in stainless steels.

When dissimilar metals are placed together in a corrosive, an electric current is set up at the junction and an electrolytic type of corrosion results which is proportional to the amount of current flowing. The intensity of this current flow is greater when the metals are further apart in the electrochemical series and varies with the relative size of the exposed areas.

Electrolytic corrosive action may also take place by current flow formed thru differences in the metal-ion concentrations resulting from the corroding metal, or thru differences in oxygen concentration, these occurring in crevices, pits, or recesses in the metal, or between different metals, or even between metals and non-metallic objects. This is generally known as a concentration cell type of attack or may be otherwise designated as metal-ion concentration cell, oxygen concentration cell and crevice or contact corrosion.

Copies of this article reprinted on heavy stock for convenient filing are available on request.

The **COOPER ALLOY** Foundry Co., Hillside, N.J.

Economics of the Small Independent Steel Plant

(Continued from p. 120)

"modern" furnaces and operations. Mr. McQuaid specifies what he means by "modern"—a removable roof for top charging; a furnace of such height that the roof life is well over 100 heats; a mechanically tripped charging bucket; cold charge dense enough so the furnace can be loaded in not more than one recharge; voltages of 450 and even higher, up to the carrying capacity of the graphite electrodes, which in turn should be of maximum diameter; rapid-action electrode controls; proper tonnage incentives to the furnace crew. In such a furnace a full heat can be melted flat in not more than 90 min. with a single recharge—that is to say, single-slag carbon heats can be made in less than 3 hr. tap to tap, or 20 tons per hr. from a 60-ton furnace. Power consumption is 475 to 500 kw-hr. per net ton of steel.

It should be borne in mind that Mr. McQuaid's discussion is based on 100% cold metal charge in either electric or openhearth furnaces. He devotes considerable attention to this problem of raw material, and notes that the cost of scrap is quite variable (in boom times all that the traffic will bear, and in slack times as little as the mills will pay) and the cost of pig iron or hot metal much more stable. This affects the "break even point" in annual tonnage where the electric furnace can compete with the openhearth mill. These fluctuations, he infers, are not enough to affect his argument that a small electric plant, at least 100 miles from a freight basing point, can make steel at a lower price than it can be shipped in from steel-producing centers—if there is sufficient scrap available in the neighborhood and power can be bought for 8 mils per kw-hr.

He believes that melting stock can even now be produced in competition with scrap, by reduction of high-grade iron ore concentrates by hydrogen (by-product of carbon black plants). Direct smelting of intimate mixtures of iron oxide and coke under the electric arc is a second possibility for the future.

He is also a great believer in modern, high-speed, labor-saving rolling mills. Such isolated plants as he contemplates would start with small ingots and should produce only a few closely related shapes. Eventually, he believes, that continuous casting of slab ingots 3 in.

(Continued on p. 124)

FROM THE TOP STEEL PRODUCER . . .
TO A LEADING CHEMICAL HOUSE,
A YEAST COMPANY
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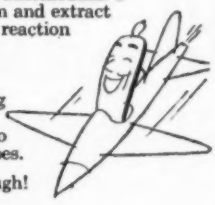
AMMONIA: Many centuries. I helped the ancient Egyptians bleach cloth 3,000 years ago.

EMPLOYER: Amazing! But what do you do today?

AMMONIA: I grow farm crops, make ice, purify water, produce explosives.

EMPLOYER: I know you are a fertilizer, a refrigerant, and . . .

AMMONIA: Yes, and I serve as a protective atmosphere to surface-harden and anneal vital parts of planes and automobiles. I neutralize acid in petroleum and extract metals from ores. I'm a solvent and reaction medium in organic synthesis, a nutrient for yeast and a processing agent in the manufacture of alkalis, rayon, dyes, butadiene, and catalysts for cracking petroleum. I'm used in making vitamins, sulfa-drugs and radio and television parts and tubes.



EMPLOYER: Whoa—that's enough! What can you do for us?

AMMONIA: Just let one of our technical men talk it over with your chemists. He can usually find an answer that will speed up some process and save you dollars.

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40 Rector Street, New York 6, N. Y.

*Reg. U. S. Pat. Off.

Economics of the Small Independent Steel Plant

(Continued from p. 122)

thick as maximum and at a minimum rate of 1 ton per hr. will be realized; these ingots can be rolled directly into flats (or shapes, if some sort of "dividing" rolls or slitters can be used in early passes).

ELECTRIC FURNACE FOR CARBON STEEL

Because the manufacture of tool-steel is normally regarded as the bailiwick of the electric furnace, together with the production of highest grade alloy and stainless steels, it may surprise some to find that Mr. McQuaid argues that the electric furnace has definite advantages over conventional openhearths and bessemers for plain carbon steel as well. He says the electric arc furnace is better adapted for both rimmed and semikilled carbon steel because it can produce steel with higher content of iron oxide and the temperature during refining and at tap is under much better control. It has also "proven itself to be definitely superior to either the openhearth or the bessemer in the production of high-sulphur steels made especially for improved machinability" (0.25% S, 1.0% Mn) since additions of silicon and aluminum are entirely unnecessary (both of which produce abrasive inclusions and increase machine tool costs) and since the tapping slag can contain 30% FeO or more (which produces ingots of far better surface quality and low "conditioning" costs in the rolling mill).

E. E. T.

Solidification of Gray Iron*

THE APPLICATION of thermal analysis techniques used to study the solidification of steel has been extended to similar investigations for gray cast iron. Gray cast iron compositions whose carbon equivalents ranged from 3.50 to 4.45% were prepared from Armco iron, graphite, ferrosilicon (50%) and ferromanganese. All compositions were innoculated with 0.5% silicon. All

(Continued on p. 126)

*Abstract of "Solidification of Gray Iron in Sand Molds", by R. P. Dunphy and W. S. Pellini, Naval Research Laboratory Report 3792, Jan. 17, 1951. (Distributed by the Office of Technical Services, U. S. Department of Commerce.)

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...Says Presmet Corp.

"Quality component parts for nearly every conceivable field are successfully sintered in our Westinghouse continuous belt conveyor furnace," reports Presmet Corporation. The furnace is used for sintering copper, brass, bronze, iron and steel, and also for copper and brass impregnation of iron and steel parts.

This is the second Westinghouse heat-treating furnace now employed by Presmet Corporation. Decision to add another Westinghouse unit was based on their record of furnace performance and the high degree of Westinghouse service.

Gas-fired or electric, there's a Westinghouse furnace to meet every heat-treating need. For toolroom application or continuous-line high production, it's your assurance of an unbiased answer to your all-important problem. Get the facts from your Westinghouse representative. Write today for new 40-page book B-5459, "Harnessing Heat". Westinghouse Electric Corporation, Industrial Heating Department, Meadville, Pennsylvania. J-10374

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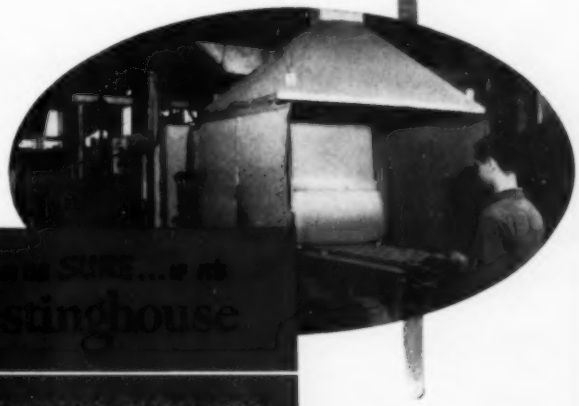

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In addition to this savings there is also an economy in cylinder handling costs and shipping charges. For it is a known fact that dissociation of one cylinder of ammonia yields the equivalent of 34 cylinders of hydrogen.

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Solidification of Gray Iron

(Continued from p. 124)

heats were allowed to cool in the ladle from 150° F. above the pouring temperature and poured into green sand molds having 3.5% moisture. The test castings were 7 x 7 in. in cross section and 30 in. long and the solidification temperature was obtained from thermocouples located in a plane through the casting at its vertical midpoint and in the same plane through the sand mold which was 8½ in. thick. With the exception of the mold-interface couple, all thermocouples were sheathed and each thermocouple was read every 8 sec.

The sequence of events during the solidification consists first of rapid removal of superheat, during which time the thermal gradients through the casting, except very near the surface, are not very steep. At the same time, cooling below the liquidus temperature at the surface has occurred and austenite dendrites have formed which initiate the "dendrite start wave". Latent heat of fusion release accompanying dendrite formation prevents the interior parts of the casting from cooling below the liquidus temperature until they are reached by the "dendrite start wave". During superheat removal, only a fraction of the possible dendritic solid material is developed at the surface where the temperature was found to be only slightly below that of the liquidus.

The second event during solidification is the progression of "dendrite start wave" toward the center of the casting. When this wave reaches the center, the surface temperature indicates only about 50% of the possible dendrites have been solidified at the surface. After a considerable time lapse the dendrite formation is completed at the surface and, in turn, "the dendrite-end wave" progresses through the casting until the carbon enriched interdendritic liquid has attained the eutectic temperature. However, a solid skin is not developed during the greater part of the austenite-dendrite formation period.

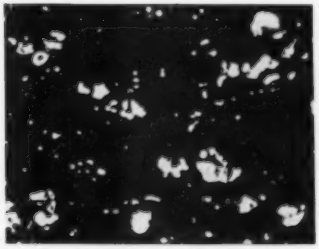
The third step in the sequence involves eutectic freezing which begins at the surface immediately at the end dendrite formation. Near the surface the "dendrite-end wave" and the "eutectic-start" move together toward the casting center but progression of the eutectic

(Continued on p. 128)

Tool Steel Topics

BETHLEHEM STEEL

Ten Times More Necktie Clasps with Hobbed Molds of Duramold A



The white particles are extremely hard carbides which are distributed throughout this hardened structure of Lehigh H, enlarged 500 times in this micrograph.

These Two Carbide Steels for High Wear-Resistance

We're talking about Lehigh H and Lehigh S, two of our high-carbon, high-chromium grades of tool steel. Both are classed as carbide steels because they're intermediate between low-alloy tool steels and sintered carbides.

Lehigh H contains about 20 pct of carbide by volume, and Lehigh S about 30 pct. It's this high percentage of carbides that makes them wear and wear, even on severe jobs.

In actual service, the "soft" material (around Rockwell C-60) wears out between the carbides, leaving the carbides protruding just like individual stones in a cobblestone street. Lehigh H and S, with their abundance of hard carbides, far outwear lower-alloy tool steels.

Lehigh H is the most popular type of air-hardening tool steel where maximum production and freedom from distortion are essential. It's the general-purpose grade. Lehigh S has a higher carbon content to provide still greater wear, but at some sacrifice of shock-resistance.

Lehigh H is stocked in our mill depot in a wide range of sizes. It's also available from local stocks of Bethlehem tool steel distributors in principal cities.

Like to know more about these long-wearing die steels? Write us for Booklet 262. It gives details of both our oil- and air-hardening grades. Address your request to Publications Department, Room 1040, Bethlehem, Pa.

Here's another enthusiastic report on Duramold A, our 5 per cent chromium, air-hardening hobbing steel. Hobbed for zinc die castings, this special-purpose steel has upped the life of molds by at least 1000 pct, according to Peerless Engineering Co., Inc., South Gate, Calif. In the casting of novelty necktie clasps, the die sets of Duramold A were examined at a time when previous molds had to be discarded. The Duramold A cavities showed no evidence of checking or sinking; and the surface finish appeared to have actually improved with use.

M. T. Derby, chief tool engineer for Peerless, sums it up:

"We like Duramold A because it's easy to hob. In making multiple cavities we get good detail and accuracy with fewer machine-hours. For most of our work we need a steel that gives us a high polish in the cavities with a high hardness that will stand up under zinc-injection molding at high pressures and temperatures. We've found Duramold A to have good core strength, it doesn't sink readily, and we can expect to get long runs with very little maintenance."

Whether used for die-casting or plastic-molding Duramold A is a real improvement over hard-to-hob steels. Its 5 pct chromium content provides plenty of wear-resistance and core strength . . . and its air-hardening properties hold distortion to a minimum during heat-treatment. Its typical analysis:

C	Mn	Si	Cr	Mo
0.07 max	0.40	0.20	4.50	0.45

Duramold A is hobbed in one push in a 300-ton press by the master hob shown at top. Eight necktie clasps are cast at one time, the molten zinc being injected at 800 F and 2000 psi; mold temperatures reach about 500 F.

Booklet 271 will help you select the right tool steel—for hobbed molds, machine-cut molds, or master hobs. Address your request to our Publications Department, Room 1041, Bethlehem, Pa.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Here's why upset-forged discs are best for some tools

Like wood, steel has a grain. Tool steel dises which have been upset-forged have a grain-flow parallel to the dise face. When a dise is cut from bar stock, the grain flow is at right angles to the dise face. Before making tools from round dises, it's best to consider the importance of the direction of grain flow.

A milling cutter, for example, made from an upset-forged dise has a radial grain-flow in the cutting teeth. There's less chance of having these teeth break out than if the cutter were made from a dise cut from a bar.

Upset-forged dises are made by upsetting a piece of tool steel which is twice as thick as the desired thickness of the dise. This upset ratio of 2 to 1 should not be varied too greatly. A ratio of more than 3 to 1 will cause buckling during upsetting; less than 1.5 to 1 will not produce the desired flow lines of the grain.

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Solidification of Gray Iron

(Continued from p. 126)

solidification is retarded while the "dendrite-end wave" is not. The completion of the dendritic-end wave produces a eutectic isothermal at the center of the casting. The surface temperature of the casting cannot drop below the eutectic range until the surface eutectic liquid has solidified. Following completion of dendrite formation, eutectic solidification proceeds toward the center of the casting.

High levels of superheat cause a time delay in the dendrite-start wave while the superheat is being dissipated into the mold wall. The time displacement of the following solidification waves is 2 to 3 times that of the delay in the dendrite-start wave. Final solidification is prolonged more than indicated by the initial delay. The dissipation of superheat causes a heating of the mold wall, so that the solidification begins with a heated mold wall.

Variations as related to the carbon equivalent indicate that the total elapsed time between start of solidification and final solidification is not significantly affected by the composition variations. A decrease in the time for the completion of the dendritic phase is almost compensated for by longer times for eutectic solidification. The effect of superheat due to composition variations at a pouring temperature of 2306° F. is small, and due to composition variations at a pouring temperature is about 10%. However, compositions poured at 2500° F. needed 25% more time to solidify when poured at 2300° F.

Additions of sea coal to the sand mixtures were found to provide an increase in the rate of progression of all phases of solidification. The time required to dissipate superheat was reduced 50%, resulting in an earlier dendritic-start wave. Sea-coal additions were found to provide a cumulative decrease of 15% in final solidification time of a casting. Mold temperatures for sand mixtures containing sea coal were lower than for mixtures without sea coal when the pouring temperatures were high, and the reverse was true when pouring temperatures were low.

The mold depth at which the 212° F. temperature hold is found is greater for cast irons than for cast steels, this is probably due to the longer time required for solidification.

D. C. Williams

Reynolds
ALUMINUM REPORTER

★ ★ ★ Tenth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

FORMING TECHNIQUES MODIFIED WITH ALUMINUM

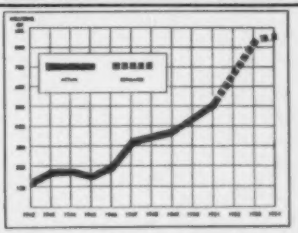
Aluminum Offers Greater Conductivity Per Dollar in the Electrical Field

In this field, it is electrical conductivity that counts, not the weight or volume. And in this respect, it's of real interest to know that a recent cost comparison shows every pound of aluminum saves $0.31 compared with the cost of copper of equal conductance. It is this saving of almost two-thirds in material cost that is focusing the attention of the entire electrical industry on aluminum.

It is interesting to note that overhead transmission lines are now almost 100% aluminum; rural distribution is mostly with aluminum; and aluminum for city distribution, telephone cable and bus conductor is rapidly being adopted. Aluminum is also acceptable and now being tried for insulated building wire and power cable, for automotive wiring, and magnet wire applications.

Rapidly increasing production of aluminum and unequalled abundant ore resources make the outlook increasingly bright for a greatly expanded use of aluminum in the electrical field in the coming years (see chart below).

STILL MORE ALUMINUM COMING



The expanding primary aluminum production of Reynolds Metals Company . . . a historic chapter in the company's 33 years of continuing growth.

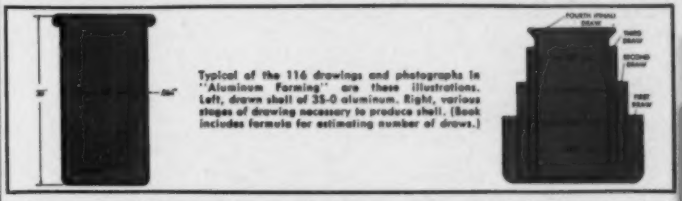
Reynolds Technical Specialists are available for assistance on specific electrical applications of aluminum. For information call the Reynolds office listed under "Aluminum" in your classified telephone directory or write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

New, Light Aluminum Crutch

A new, vastly superior aluminum and wood crutch is now on the market. According to the manufacturer, Pioneer Crutch and Cane Company, Lisbon, Ohio, the use of aluminum is far more economical despite a slightly higher raw material cost. This new, adjustable crutch requires only three or four manufacturing steps against twenty steps for the construction of an old-time, all-timber crutch.

Designer's Selection of Alloy and Temper Affects Production Costs, Product Efficiency

For some applications, design and fabrication practices with aluminum are similar to those used with other metals. In many cases, however, modifications and possibly even special procedures are required. Selecting the proper grade of aluminum for each specific application is also of utmost importance.



Typical of the 116 drawings and photographs in "Aluminum Forming" are these illustrations. Left, drawn shell of 3S-O aluminum. Right, various stages of drawing necessary to produce shell. (Book includes formula for estimating number of draws.)

To acquaint design engineers and plant supervisors with the proper techniques for working aluminum, Reynolds has just released a new handbook, "Aluminum Forming". This latest addition to Reynolds Technical Library of informative literature is a 148 page, 6" x 9" book. It is clearly illustrated with 116 drawings and photographs and has many valuable tables.

New Aluminum Diffuser Offers Simple, Efficient Control of Air Flow

A new diffuser with an exclusive adjustment feature has been developed by J. M. Marr of the Aladdin Heating Corporation, Oakland, California. This diffuser, provides a controlled variable air pattern that can be adjusted to any angle of discharge from horizontal to vertical flow. Adjustments are simple, require no tools and can be made easily by the finger tips. A turn of only 11½ degrees covers the complete range from horizontal to vertical flow. On the face plate, the slotted pieces are folded back to act as deflection fins; the other plates are completely blanked out.

From a manufacturing standpoint, aluminum was chosen for this diffuser because it is easy to blank, form and handle in production. Also, it aids in prolonging tool life. From a sales standpoint, aluminum offers a rustproof, stainproof surface which presents an attractive appearance in its natural form to harmonize with all color combinations. This also helps keep costs down.

"Aluminum Forming" is divided into four major sections. Section I is devoted to metallurgical and technical data pertaining to aluminum sheet . . . data essential for designing and fabricating aluminum sheet products.

Section II covers various types of sheet forming operations. Included is data on shearing and slitting, blanking and piercing, hole flanging, bending and pressing, rubber forming, continuous roll forming, drawing and ironing, bulging, necking, curling, beading and roll flanging, drop hammer forming, stretch and contour forming, embossing and coining, stamping and spinning.

Section III presents data on aluminum tubing and pipe comparable to that in the first section on sheet. Section IV discusses the forming, bending and swaging of aluminum tubing and pipe and includes information on machine, press, stretch, roll and hand forming methods.

In case of special aluminum forming problems, Reynolds also offers the services of its trained staff of aluminum specialists. They are available to work with manufacturers on aluminum designs and to help set up for fast, economical production. For prompt service, call the Reynolds office or distributor listed under "Aluminum" in your classified telephone directory, or write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Ky.

For your free copy of the valuable handbook described above, plus a complete index of Reynolds technical literature, write on business letterhead (otherwise price is $1.00) to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

(Advertisement)

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(Continued From Preceding Page)

Aluminum Foil Cuts Ironing Drudgery, Adds Big Sales Building Feature

Here's an application where the high heat reflectivity of aluminum really pays off! Wise thinking on the part of the Merkin Company, Boston, Mass., led to the development of their new "FOILIN" ironing board pad that employs an inner liner of Reynolds Aluminum foil between two layers of cotton wadding.

The aluminum foil reflects heat from the iron back into the work. This irons the work drier and irons it faster . . . actually cuts ironing time in half. The cotton wadding provides a multitude of small air spaces that permits heat to "bounce" back from the aluminum. Thus heat is applied to the work from both sides, resulting in much greater ironing speed.

The Reynolds Aluminum foil used in the "FOILIN" ironing board pad is stitched and handled as easily as the cotton materials, so operations in the stitching and cutting room are greatly simplified. Also, each pad actually uses only a small amount of foil, so that the cost of material is exceptionally low on a unit basis. The usefulness of the pad will not decrease, as the aluminum will retain its great heat reflectivity almost indefinitely. Tests have shown that ordinary conditions of use such as encountered here do not decrease the reflectivity more than a few percent over many years of use. Also aluminum is immune to rust, rot, mildew and insects.

For information on Reynolds Aluminum foil and its possible applications in your products, call the Reynolds office listed under "Aluminum" in your classified telephone directory. Or write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Return Flight Guaranteed.

New Piasecki HUP Helicopter Designed To Carry Out Many Essential Duties in Navy Shipboard Service

Reynolds Aluminum Used for Strength, Weight Saving and Ease of Fabrication

More wings for the Navy now are being delivered in the form of a tandem rotored helicopter, the HUP, made by Piasecki Helicopter Corporation, Morton, Pennsylvania. The HUP is equipped with an automatic pilot and is a 6-place model designed for shipboard service. It will be used by the Navy aboard Fleet carriers and cruisers for plane guard rescue, anti-submarine patrol and ferrying personnel and cargo between ship and shore.

In speed trials, a prototype of the streamlined HUP made calibrated runs at 131 miles per hour. This high speed, plus a fast rate of climb, is basically due to relatively low structural weight in relation to available power. And Reynolds Aluminum is used to help achieve the favorable weight-power ratio. In addition to providing light weight with strength, the rigid, all-metal fuselage has curtailed vibration in the Piasecki HUP.

Merchant and Evans Company, Reynolds distributor of Philadelphia, supplies Piasecki Helicopter Corporation with aluminum. Merchant and Evans also supplies Reynolds Aluminum sheet, strip, wire, rod, bar, tubing and structurals to other leading manufacturers in many diversified fields. To locate your nearby Reynolds office and distributor for fast service on design and production problems, look under "Aluminum" in the classified telephone directory.

Reynolds Offers Complete Fabricating Service for Aluminum Parts

Bright, color-anodized aluminum refrigerator shelving, door trays and crisper pans, plus evaporators and home freezer liner panels are examples of parts mass-produced by Reynolds Aluminum Fabricating Service to quality standards exceeding industry requirements.

The many advantages of aluminum are clearly demonstrated in the Reynolds fabricated evaporators shown below. No other material offers the serviceability of rustproof, stainproof, light yet strong aluminum. No other material offers a better combination of economy and efficiency in rapid heat conduction. Reynolds embossed aluminum sheets add to evaporator rigidity, provide surfaces that resist scratching.

Reynolds will be glad to work with you on your requirements for aluminum blanks and parts, or on development work for future application. Contact the nearby Reynolds office listed under "Aluminum" in your classified telephone directory, or write Reynolds Metals Company, Parts Division, 2065 South Ninth Street, Louisville 1, Kentucky.

Aluminum Carts Speed-up Handling, Reduce Breakage of Costly TV Tubes

Ten out of eleven major TV tube manufacturers are now relying on aluminum push carts made by Bucks County Enterprises, Inc. of Quakertown, Pennsylvania, to transport precious picture tubes within their plants.

These aluminum carts replaced the cumbersome plywood and angle iron equipment formerly used. Lightweight aluminum speeded up handling and reduced tube breakage. Upkeep is no problem as aluminum is rustproof, decay proof and corrosion resistant. Ease of operation of these carts also helps in keeping down labor turnover in departments where the carts are used.

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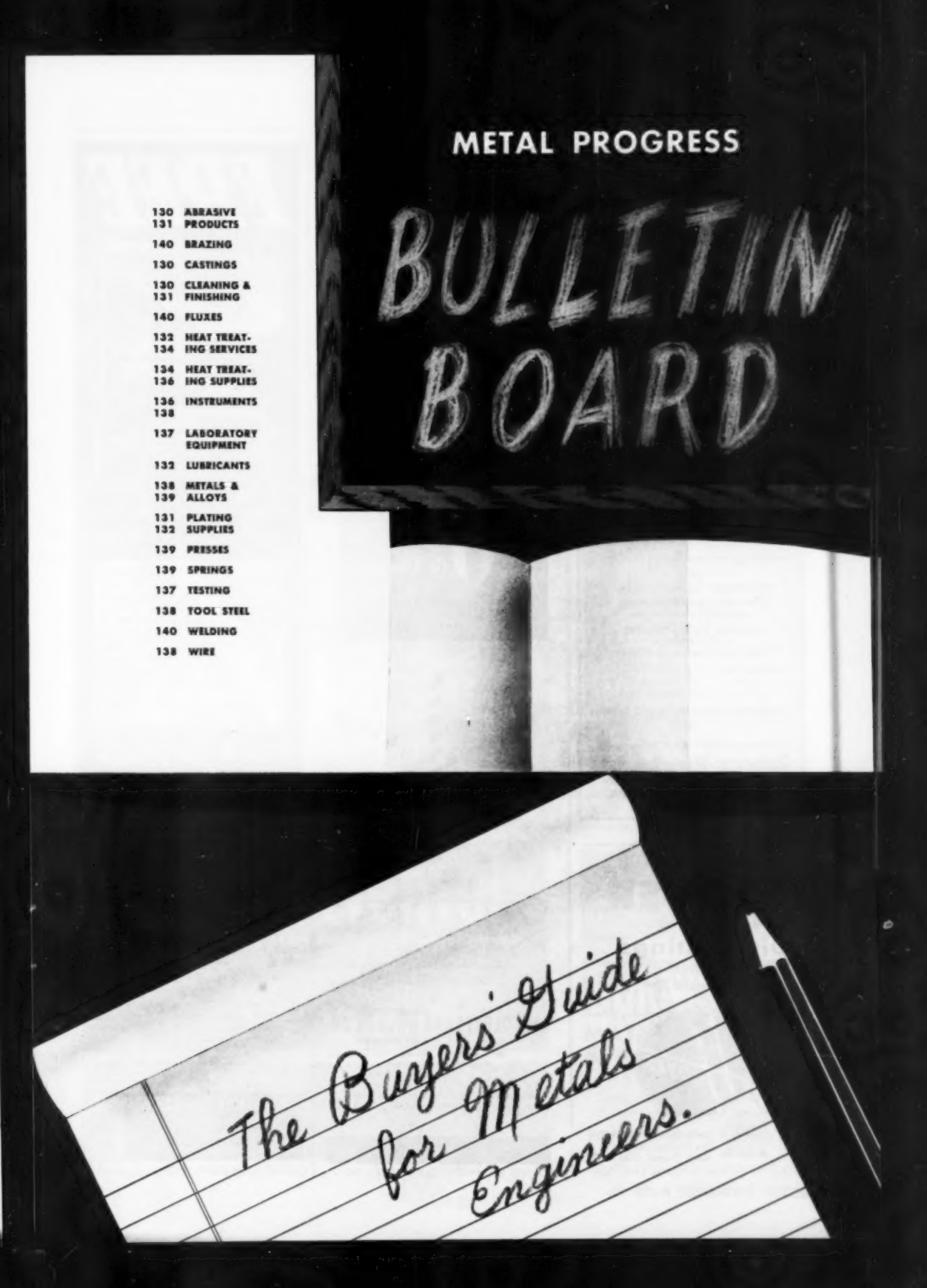
METAL PROGRESS
BULLETIN BOARD
130 ABRASIVE
131 PRODUCTS
140 BRAZING
130 CASTINGS
130 CLEANING &
131 FINISHING
140 FLUXES
132 HEAT TREAT-
134 ING SERVICES
134 HEAT TREAT-
136 ING SUPPLIES
136 INSTRUMENTS
138
137 LABORATORY
EQUIPMENT
132 LUBRICANTS
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139 ALLOYS
131 PLATING
132 SUPPLIES
139 PRESSES
139 SPRINGS
137 TESTING
138 TOOL STEEL
140 WELDING
138 WIRE
The Buyers' Guide
for Metals
Engineers.

MANHATTAN

Abrasive Wheels — Cut-off Wheels
Finishing Wheels—Diamond Wheels

Custom-made for your specific material removal problems

Foundry Snagging—Billet Surfacing—Centerless Grinding
Cutting and Surfacing concrete, granite, and marble
"Moldiscs" for rotary sanders
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Grinding Carbide Tipped Tools

Write to Abrasive Wheel Department

Raybestos-Manhattan, Inc.
MANHATTAN RUBBER DIVISION
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SPECIALISTS IN THE FIELD OF

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SINCE 1922

Aluminum and Zinc

THE HOOVER COMPANY
Die Castings Division
North Canton, Ohio

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Which is better for YOUR product?

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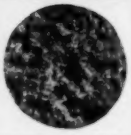	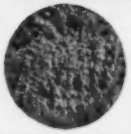

• *Request Booklet!*

American Non-Gran Bronze Co., Berwyn, Pennsylvania

NON-GRAN — PRECISION MACHINE WORK — CASTINGS, SAND & CENTRIFUGAL

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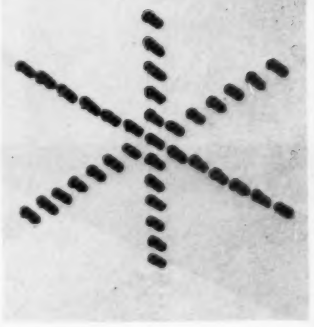
20th Century



Any reference to 20th Century Drawn Steel Shot will emphasize its highest quality, economy and ability to stand hard use.

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800 East 67th Street Cleveland 3, Ohio
Howell Works Howell, Michigan

One Of The World's Largest Producers Of Quality Abrasives
Normalized (Copyrighted Trade Name) Hard Iron Cut Wire Powder

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FREE

This amazing 22-page booklet is *guaranteed* to open your eyes! Gives latest, up-to-the-minute facts – figures – photos on advanced barrel finishing. Shows how single unit installation replaces from 2 to 12 men—*savings up to 95%* on almost all types of parts from large castings to small intricate parts.

Investigate today! Send for your FREE copy of Booklet No. J-7 today.

ALMCO Supersheen

AMERICA'S LARGEST MANUFACTURER OF ADVANCED BARREL FINISHING EQUIPMENT—MATERIALS AND COMPOUNDS

ALBERT LEA, MINNESOTA

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Whether your washing jobs are

BIG.. OR SMALL

INDUSTRIAL WASHING MACHINES
handle 'em all . . .!

The type of work . . . the cleaning and/or treating . . . and maintaining high production present no problem to INDUSTRIAL machines. This specialized equipment washes . . . rinses . . . dries . . . phosphatizes . . . treats with Bonderite . . .; and performs other desired single or combined preparing and finishing operations. Address Dept. BB NOW!

INDUSTRIAL SYSTEMS COMPANY
Exclusive Sales Agents
for Industrial Washing Machine Corp.
New Brunswick New Jersey

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CIRCO
VAPOR DEGREASERS
and
Metal Parts
Cleaning Equipment
PER-SOLV (Perchlorethylene)
CIRCO-SOLV (Trichlorethylene)
Write for Bulletin
1001
TOPPER EQUIPMENT COMPANY
MATAWAN, NEW JERSEY
OFFICES IN PRINCIPAL CITIES
MANUFACTURERS OF VAPOR DEGREASERS
AND METAL PARTS CLEANING EQUIPMENT

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PLATING RACKS
for Defense
Designed and Manufactured
for Anodizing, Plating and all
Specialized Finishes.
NARACO

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Attention SHELL MANUFACTURERS !
Your cleaning problems can be
handled more economically and
with less floor space—by using
ROTARY SHELL WASHERS
—Any Number of Stages—
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Solventol
originators of DI-PHASE metal cleaning
DESIGNERS & BUILDERS OF SPECIALIZED METAL CLEANING EQUIPMENT

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ABBOTT
BURNISHING
MATERIALS
& BARRELS
for SUPERIOR RESULTS
Manufacturers of Deep Hardened and
Tempered Carbon Steel Bearing Balls
THE ABBOTT BALL CO.
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RHODIUM Plating

In these days of restrictions on the use of the usual plating metals, the precious metal, rhodium, becomes important as a replacement for them, especially for small articles and parts.

Rhodium is hard and brilliantly white and it cannot tarnish. No acid nor mixture of acids attack it. Our solution has excellent throwing power.

Suggested objects for plating with rhodium are optical mounts, contacts for communication equipment, radar components, surgical instruments and pen and pencil sets. The practical plater's own experience will suggest many others to him.

Commercial rhodium plating was developed in our laboratories. Baker Rhodium Plating Solution is the original and is made under the direction of the men who developed the process.

● Let us send you *Directions for Rhodium Plating.*

Baker & Co., Inc.

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NEWARK 5 NEW JERSEY

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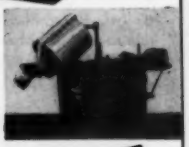
DANIELS

For economical bulk plating with fast loading and unloading features investigate the Daniels DLS Plating Barrels. Write for illustrated catalog today.



Now available, a new H series of Daniels Plating Barrels for low cost plating of small parts. Write for illustrated catalog today.

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MANUFACTURERS and DISTRIBUTORS
Electroplating and Polishing Equipment and Supplies
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Use . . .
Hangsterfer's
LUBRICANTS
for . . . Increased Production
Less Scrap
Longer Die Life

Doing the most difficult jobs for the major metalworking plants throughout the United States and Europe.

HANGSTERFER'S LABORATORIES, INC.
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New!
Sure-Wear *Heat Treating*

"Sure-Wear"—to ensure longer life in all types of high speed cutting tools!

L-R Heat Treating Co. research has developed a new process for heat treating of all types of high speed cutting tools to ensure longer tool life than ever before.

Specify "Sure-Wear" to be sure.

"Mirror-Finish" is another L-R exclusive process. Ask for details.

L-R is equipped for quantity production work. Metallurgical and laboratory service available.

Tool and Die Hardening . . .
Precision Heat Treating . . .
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Cyaniding . . . Pack Hardening
Annealing . . . Normalizing
Brazing . . . Nitriding
Also all non-ferrous Heat Treating
Pick-up and delivery (5 Trucks)

LR HEAT TREATING CO.
QUALITY STEEL TREATING
107-11 VESEY ST. NEWARK 5, N. J.
Equipped for Large Quantity Production Work

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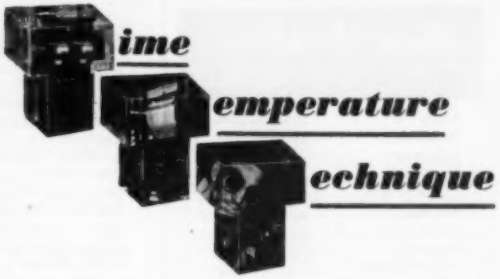
first in the Three T's of Scientific Steel Treating...

WHETHER it's the treating of your rough forgings, castings and bar stock, or your finish-machined parts—the 3 T's of Scientific Steel Treating are at work for you. From the unbiased, scientific recommendations of your Lakeside metallurgists, through the perfected, fully mechanized, electronically-controlled processes, to instrumented, precision testing—Science directs every step. No chance for guesswork, or human error. Only with the finest, modern facilities can you be assured of *highest steel treating quality.*



ime

emperature

echnique

Our Services—Electronic Induction Hardening, Carbo-nitriding, Flame Hardening, Heat Treating, Bar Stock Treating and Straightening (mill lengths and sizes), Annealing, Stress Relieving, Normalizing, Pack, Gas or Liquid Carburizing, Nitriding, Speed Nitriding, Aerocasing, Chapmanizing, Cyaniding, Sand Blasting, Laboratory Research, Tensile and Bend Tests.

THE *Lakeside Steel Improvement Co.*

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Large Car Bottom Furnaces
Pit Type Convection Furnaces
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Carbonitriding
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Cyanide and Neutral Baths
Carburizing
Induction Heating
Normalizing
Annealing
Grit Blasting
Shot Blasting

Complete Heat Treating Facilities...

FORGINGS, CASTINGS, TOOLS, PARTS

Special Jobs or Production Runs
Complete Heat Treating
Counsel Without Obligation

Send for Free Booklet of Complete Facilities

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Spotlighting
DETROIT'S BETTER
HEAT TREATER

OFFERING FACILITIES FOR:
1. ALUMINUM-CAP. 500,000# PER MO.
2. MINUTE PARTS TO 2-TON ONES
3. BRIGHT HARDENING OF STAINLESS STEEL
ALL TYPES OF HEAT TREATING CAN BE DONE BETTER BY
STANDARD STEEL TREATING CO.
3467 LOVETT AVE. DETROIT 10, MICH.
Phone TAshmoo 5-0600

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Heat Treating OF METALS

Flame Hardening	Stress Relieving
Induction Hardening	Normalizing
Chapmanizing	Gas, Pack or Liquid Carburizing
Nitriding	Annealing
Cyaniding	Silver-Finish Hardening of Dies or Tools
Cadmium, Tin or Copper Plating	Roto-Blasting
Anodizing or Alrocking of Aluminum	Silver or Copper Brazing

PITTSBURGH COMMERCIAL HEAT TREATING CO.
49th Street Pittsburgh, Pa.

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HAYS DIAFLOW METER

New low differential flow meter measures:

1. air flow
2. gas flow
3. or air flow–gas flow ratio

Diaflow measurement in open hearth, soaking pit, billet, slab heating and annealing furnace indicates excessive amounts of air and/or gas ... helps to prevent fuel and gas waste ... serves as a guide in maintaining product quality.

Write for bulletin 52-1017-37

BULLETIN ON HEAT TREATING FURNACES

A complete summary of Hays products applicable to processes such as annealing, brazing and calorizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO_2 recorders are covered.

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43rd YEAR
A VINCENT PROCESS
For
EVERY HEAT TREATING NEED
•
300-TON DAILY CAPACITY
•
MODERN FACILITIES
VINCENT STEEL PROCESS CO.
3426 Bellevue Ave. • Detroit 7, Mich.

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HEAT TREAT at it's Best!

COMPLETE SERVICE including —
BRIGHT HARDENING OF STAINLESS STEELS...STEAM TREATING HIGH-SPEED CUTTING TOOLS ... HARDENING ... TEMPERING ... CLEANING.
Our Metallurgical Engineers can help with your metal treating problems.

COMMERCIAL STEEL TREATING CORP.
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TYler 6-6086

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FIXTURES
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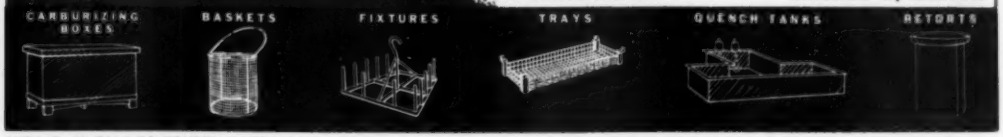
FURNACE PARTS

Every Type of Container or Holder for Handling Parts Through Heat Treating, Quenching, Pickling, Washing and Anodizing Operations
Complete Design and Engineering Service
Representatives in Principal Cities
Stanwood Corporation
FABRICATED METAL PRODUCTS
...W. CORTLAND ST. CHICAGO 39, ILLINOIS



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Serving the
HEAT TREATING INDUSTRY
Since 1930

- Complete Service on Control Equipment
- Thermocouples
- Protection Tubes
- Charts and Lead Wire

THE CLEVELAND ELECTRIC LABORATORIES COMPANY

1988 E. 66 St. Cleveland 3, Ohio

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Control Temperatures More Closely

REDUCE COST • SAVE TIME

This Catalog of Improved Pyrometer Supplies shows you how!

Get your FREE Copy Today!

★ Thermocouples ★ Protection Tubes
★ Thermocouple Wire ★ Lead Wire
★ Insulators ★ Terminal Heads

ARKLAY S. RICHARDS CO., Inc.
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CIRC-AIR

HEAT TREATING FURNACES

for Every Heat Treating Process

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CONTROLLED ATMOSPHERES

★

DIRECT FIRED

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CIRC-AIR DRAW FURNACES

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CIRC-AIR NICARB
(CARBONITRIDING)

Specially Engineered for Your Particular Needs

GAS • OIL • ELECTRIC

INDUSTRIAL HEATING EQUIPMENT

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Park MATERIALS
SINCE 1911

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- QUENCHING and TEMPERING OILS
- CYANIDE MIXTURES
- NEUTRAL SALT BATHS
- HIGH SPEED STEEL HARDENING SALTS
- TEMPERING and ISO-THERMAL QUENCHING SALTS
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- WOODSIDE RAPID CARBURIZERS
  Non-Burning Type
  Charcoal Coke
  Specifications

PARK CHEMICAL COMPANY
8074 Military Ave., Detroit 4, Michigan

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EXPLOSION COMBINATION GAS and OIL BURNER

Our burners afford low fuel consumption, substantially complete combustion (11½% CO_2 Orsat), instant lighting without preheating. Never need cleaning. Absolute metering of fuel by single control. Rapid recovery of temperature head.

Write for Free Bulletin

Ra-DIANT HEAT REFRACTORY SALES Co.
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Canton, Ohio

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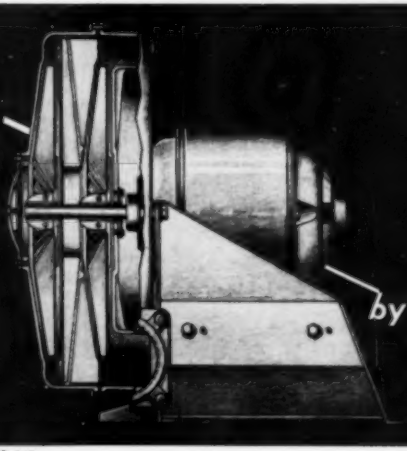
DESIGN



by North American Manufacturing Company
GAS OR OIL COMBUSTION EQUIPMENT
CLEVELAND 5, OHIO

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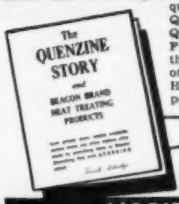
FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



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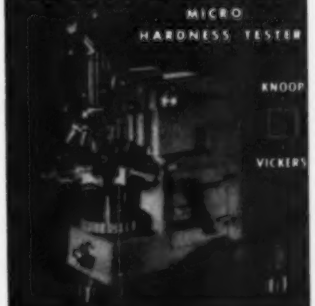

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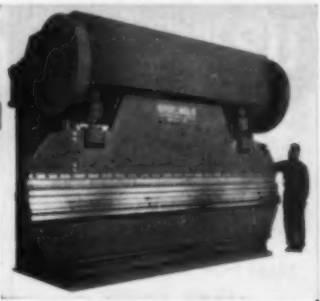

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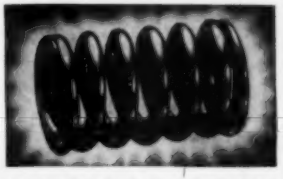

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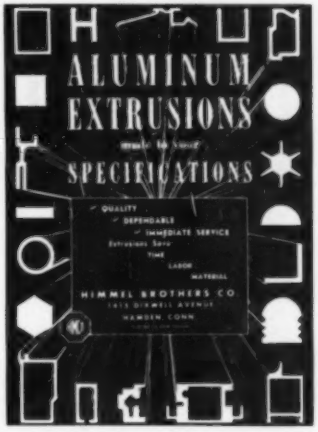

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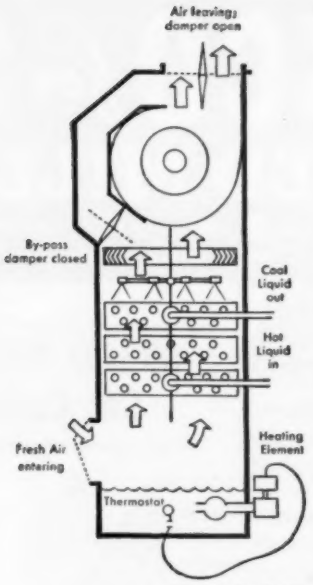
NIAGARA Aero Heat Exchanger



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Cutting Oils	Diesel, aircraft, automotive and other engines.
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For help in increasing production, saving of cooling water, write for Bulletin #120. Address

NIAGARA BLOWER COMPANY

Over 35 Years' Service in Industrial Air Engineering

Dept. MP, 405 Lexington Ave. New York 17, N. Y.

Experienced District Engineers in all Principal Cities

Electro-Machining

(Continued from p. 89)

undertaken to acquaint tool users and others with the critical diamond bort supply problem, and to discourage any wasteful use.

4. A committee should be set up to disseminate present and future pertinent information dealing with machining and grinding processes for use of governmental agencies.

SUMMARY

Conservation of diamond bort is imperative in the face of mounting demand for diamond wheel grinding of carbide cutting tools, chip breakers, milling cutters, broaches, projectile cores, dies and other hard-to-machine elements such as components of turbojet engines.

New electro-chemical, electro-mechanical and ultrasonic processes, plus combinations thereof, promise to take over some of these difficult machining and grinding jobs. Most of them are worthy of more intensified research and development, leading as rapidly as possible to large-scale industrial testing.

A limited number of machines is becoming available for practical evaluation of the new techniques. Before substantial savings of diamond bort can be realized, there must be thousands of commercially operable units, based on one or more of the new processes. A more widespread appreciation of the problem is a matter of major importance.

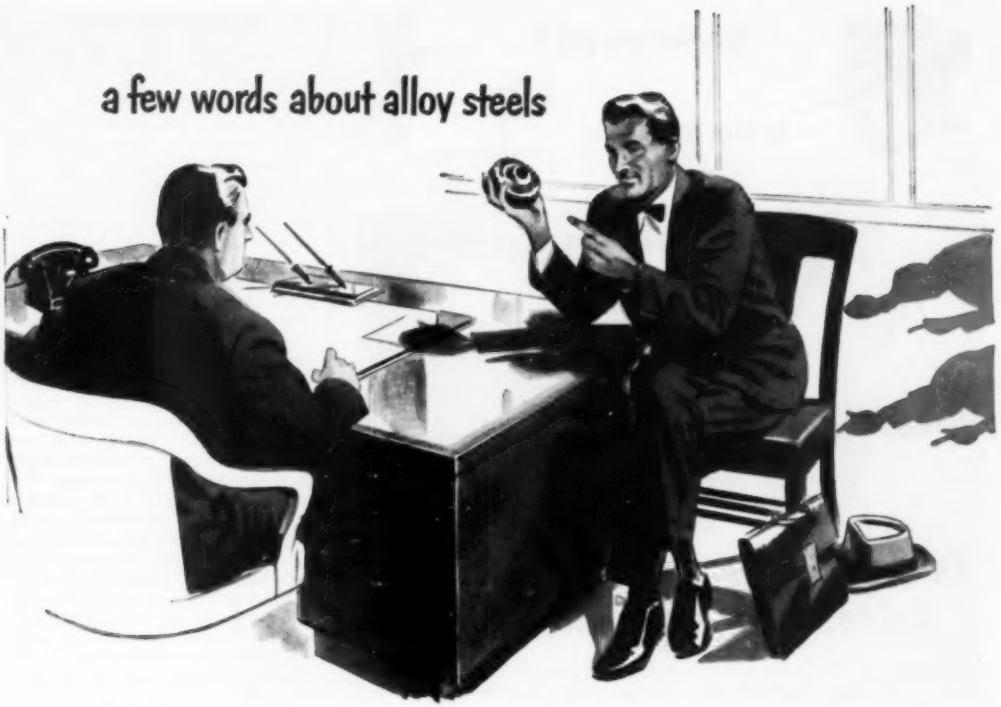
Protecting Metal Surfaces With Paint

(Continued from p. 81)

underwater exposure. It is, thus, more important that the coating be an electrolytic barrier than a moisture barrier.

The diffusion of electrolytes through organic membranes has been studied at the laboratories of the New Jersey Zinc Co. It was found that the electrolytic resistance of a paint system is largely dependent on its resistance to the diffusion of ions and does not seem to be materially affected by variations in its water permeability. The good agreement between the relative resistance to the diffusion of sodium chloride and the relative resistance to the passage of the electrolytic current led to the conclusion that salt diffusion is the property which controls the elec-

(Continued on p. 144)



or, where you can use Boron Steels, *we can help you*

If you are faced with the problems of allocations and shortages of the alloy steels you've been accustomed to use, you can probably make your job easier by shifting to Republic alternate grades or *boron* type alloy steels.

Republic has been producing boron steels commercially for more than 10 years. In that time we have made more tons of boron steels than any other alloy producer. Which means that we have solved more problems of shifting to boron alloys, have assembled more knowledge about the boron grades than any other producer.

Our 3-Dimension Metallurgical Service can give you the help you need to switch your production to alternate alloys or boron steels quickly and with the fewest headaches. A Republic Field Metallurgist analyzes your products and production set-up right in your plant. Then he goes over your case with the other two members of the 3-Dimension team... the Republic Mill and Laboratory Metallurgists.

The result? If the parts you are making from alloy steels are adaptable to *boron* steels, you'll get expert answers and recommendations that will speed you into boron-grade production promptly.

Boron steels aren't always the answer, may not solve every problem . . . your Republic Field Metallurgist will give you honest advice, backed by Republic 3-Dimension Metallurgical Service.

When may we call?

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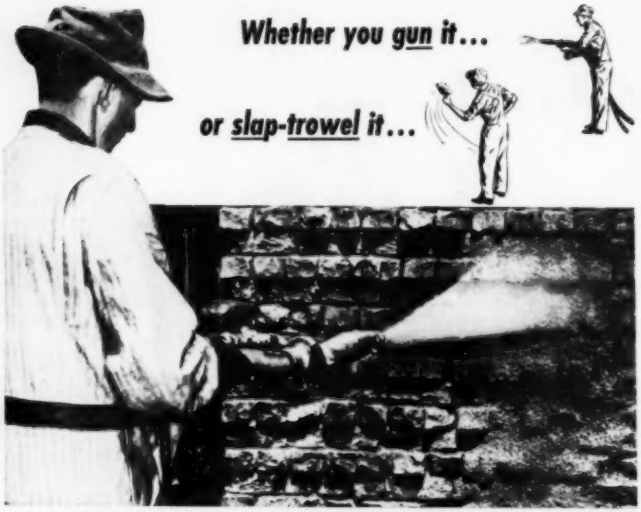

Gunning Blazecrete refractory lining on a boiler wall.

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Blazecrete* is Johns-Manville's hydraulic setting refractory that you mix with water just as you'd mix ordinary concrete. Applied by gunning or slap-troweling, it builds linings that stand up longer in severe service.

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For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for building and repairing forge furnace linings, lime kilns, burner blocks—and for lining ladles in ferrous and non-ferrous foundries.

STANDARD BLAZECRETE

For temperatures through 2400F. For building new and repairing old refractory linings. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Standard Blazecrete does not require pre-firing.

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For temperatures through 2000F. An *insulating* refractory . . . light in weight, low in thermal conductivity. For building new linings and repairing old. Adaptable and economical for many other applications.

All Blazecrete products harden on air curing . . . can then be fired or left standing indefinitely. For further details, send for Brochure RC-28A. It also tells about Blazecrete's companion material, Firecrete* . . . the hydraulic setting castable refractory for making special shapes and linings. Just write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

*Reg. U. S. Pat. Off.

Johns-Manville **BLAZECRETE**

REFRACTORY LININGS

Protecting Metal Surfaces With Paint

(Continued from p. 142)

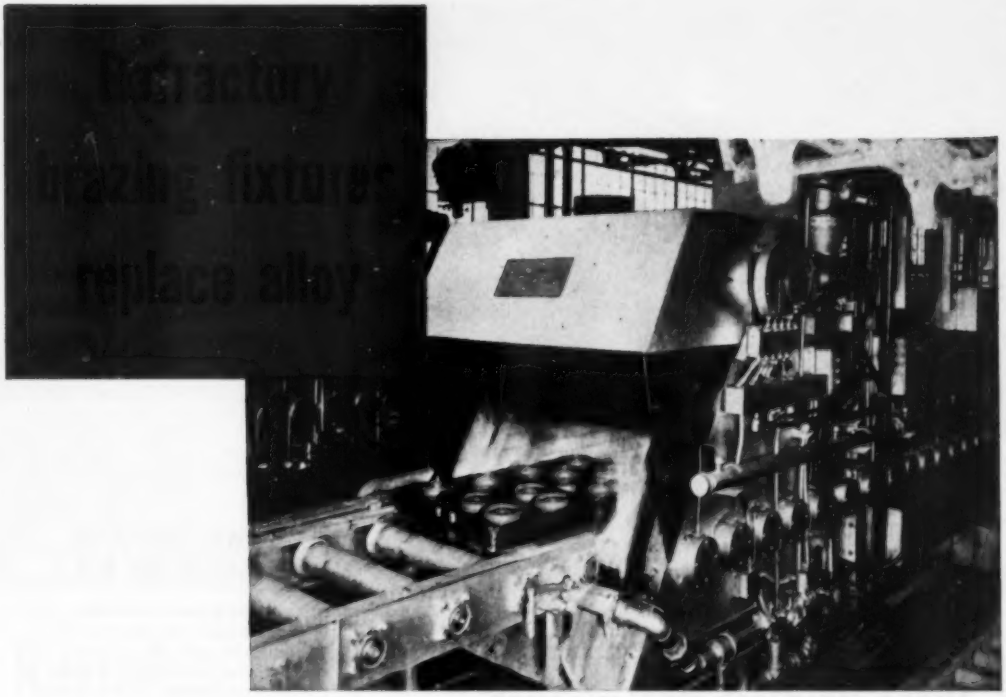
trolytic resistance of a paint system. Results of additional tests on the use of salt-diffusion rates in the evaluation of metal-protective coatings were reported at the 119th meeting of the American Chemical Society.

Selection of Pigments — Consistently good results were obtained with zinc chromate, red lead or zinc yellow (ZTO chromate) and zinc oxide pigments. Chrome yellow, which gave relatively poor results in the bodied oil vehicle, showed surprisingly good resistance to salt diffusion in the more waterproof alkyd and phenolic resins. Zinc yellow, on the other hand, gave fair results in the related linseed oil and alkyd resin vehicles and fell down completely in the highly water-resistant phenolic and polyvinyl butyral vehicles. The chemically inert pigments, iron oxide and silica, gave much more impermeable films in the highly water-resistant phenolic and polyvinyl butyral matrices than in the air-drying linseed and alkyd resin coatings.

In general, the tests showed that the incorporation of a pigment into the phenolic and butyral resin vehicles resulted in some degradation of salt impedance; if the pigments did not give other desirable properties, their use in these vehicles would hardly be justified. With these special types, the question is not so much which pigment — or pigment combination — will provide the greatest improvement in the protective value of the coating, but rather which pigment will cause the least possible loss in the superior protective properties of the binder.

For the polyvinyl butyral vehicle, these pigments are red lead, ZTO chromate, aluminum powder and zinc dust. Their use is supported, partly at least, by practical exposure tests which demonstrated that the outstanding metal-protective properties inherent in polyvinyl butyral-type vehicles can be realized when they are pigmented with ZTO chromate. Paint systems pigmented with red lead, ZTO chromate, zinc dust and zinc oxide exhibit a high resistance to the diffusion of sodium chloride, and also show good anticorrosive properties in underwater exposure. However, practical experience has demon-

(Continued on p. 146)



. . . last 5 times longer

Automotive parts go through this furnace from cold, to 2100F, to cold, in 1 hour and 10 minutes. It's brazing on a volume basis.

The fixtures holding the parts were formerly made of a special heat-resisting alloy. These warped badly, and the parts often stuck to the fixtures. Attempts to overcome the warping by making the fixtures thicker resulted in fixtures which absorbed most of the furnace heat. They also added considerable load on the roller hearth.

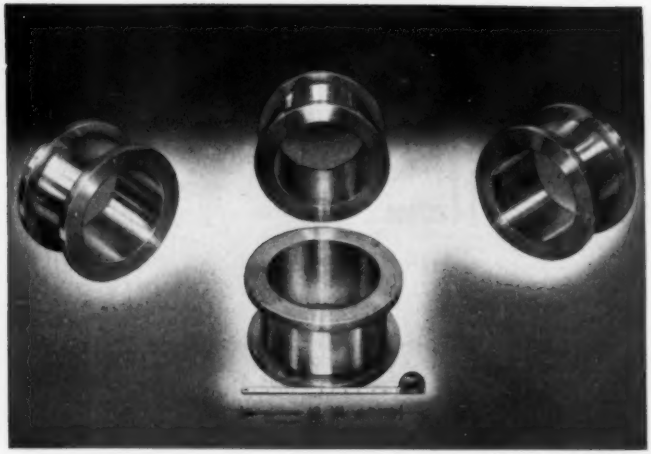
When replaced with CARBOFRAX silicon carbide refractory fixtures, the weight per loaded tray was nearly halved, sticking was eliminated, and the fixtures *now last 5 times longer*. The new fixtures, of course, cost far less than the alloy.

Think what these advantages add up to in terms of labor, materials and down time . . . savings you may be able to duplicate where heat resistant metals are used in furnaces (e.g. skid rails, muffles, radiant tubes, roller hearths, etc.). For further data address Dept. C-82. Refractories Div., The Carborundum Co., Perth Amboy, N. J.

Use Super Refractories by

CARBORUNDUM
Trade Mark

"Carborundum" and "Carbofrax" are registered trademarks which indicate manufacture by The Carborundum Company.



Forged Sleeves: 12¼" OD x 9" ID x 6⅝" long

for complete service

G. O. CARLSON, INC.

forged and rough machined

these stainless steel sleeves

Producing stainless steel forgings is not easy. That is why many plants turn this work over to the experienced personnel of G. O. Carlson, Inc. The forgings illustrated are special sleeves made of Type 302 stainless, formed first as rings and then rough machined in the Carlson machine shop. Products such as these forgings are made at substantial savings because Carlson's technical knowledge, practical skill and specialized equipment combine to do a faster job with less waste of valuable material.

Forgings, heads, diameters, rings, plates and other stainless steel specialties are regularly made by us to meet the most rigid chemical industry standards.

Contact G. O. Carlson, Inc. for your needs in stainless steel.

Stainless Steel is our only business
. . . and we know it

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Stainless Steels Exclusively
300 Marshalton Road, Thorndale, Pa.
PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)
District Sales Offices in Principal Cities

Protecting Metal Surfaces With Paint

(Continued from p. 144)

strated repeatedly that vehicles pigmented with zinc yellow give coatings of excellent anticorrosive properties in spite of a marked tendency to blister during prolonged underwater exposure. It is probable that zinc yellow paints do not owe their superior properties to a high resistance to the diffusion of salt, but rather to the passivating effect of the soluble chromate ions they contain.

Thus, it may be concluded that a protective paint coating represents a compromise between many, often contradictory, properties; no single film property absolutely determines the over-all behavior of the paint coating during service.

German Report on Welding in the U.S.*

THE development of welding has been greatly accelerated during the last war and the post-war period, although the actual progress of welding technology varies widely in the different fields. Thus, for example, riveting is still the predominantly used method of bridge construction; in general, welding is the most widely used process for joining metals. (Reviewer's comment: It is inferred here that the application of welding to bridge construction has not been developed in U.S.A.) Also noteworthy is the freely continuous way in which welding is combined with other joining methods on the same piece of work. Another common practice is the combination of various welding and soldering (or brazing) processes on the same job.

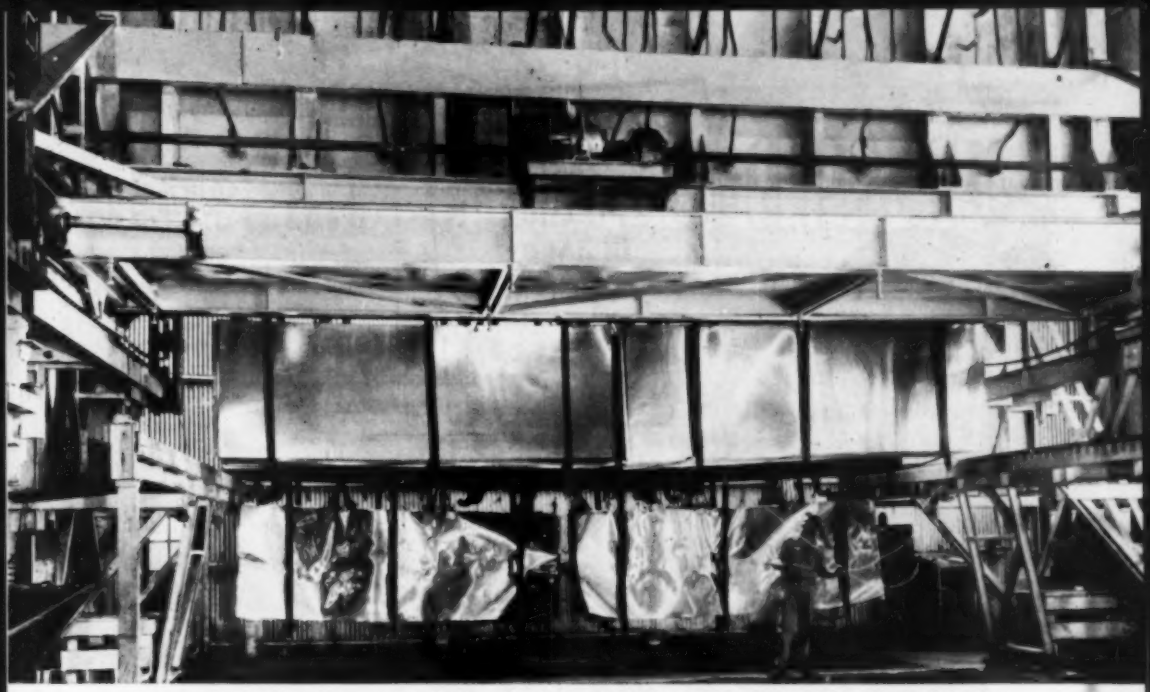
With respect to the application of various welding, soldering or brazing processes, the following points are stated in summary:

1. Manual arc welding is the predominant fusion welding process; coated electrodes are used exclusively. "Deep-burning", "con-

(Continued on p. 148)

*Abstract of "Welding Technology in the U.S.A.", by H. Von Hofe, E. Kauhausen, H. Koch, K. L. Zeyen and E. Zorn. *Schweissen und Schneiden*, Vol. 3, December 1951, p. 359-370.

Observations made by the German members of Tour Group 5 (Welding and Joining) during their visitations to American plants as part of the program of the first World Metallurgical Congress are reported in this article.



ELEVATOR FURNACE NEARS 10 YEARS SERVICE OF CONSISTENT, ACCURATE TREATMENT OF HIGH-QUALITY ALLOY SHEET.

Reynolds Metals Co. Says "G-E Furnaces Meet Heavy Schedule, Need Few Repairs"

Their Listerhill, Alabama, plant is now operating at full capacity to meet the ever-increasing demand for aluminum. And to meet this high production schedule, Reynolds depends on many types of G-E electric furnaces for annealing, aging and solution heat-treating.

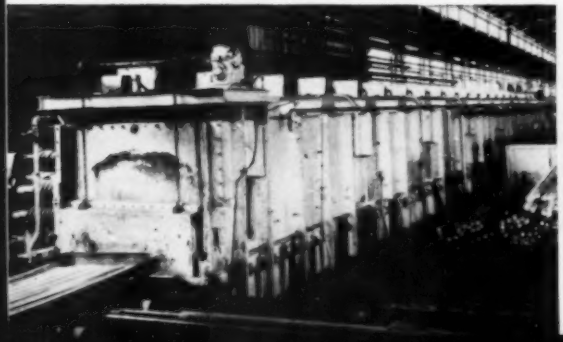
MR. M. A. J. PHILLIPS, Reynolds Vice-president, says, "We are very pleased with the dependable service our G-E furnaces give with little downtime." One of his engineers adds, "Uniform heat distribution is very important in aluminum heat-treating, and the consistent high-quality work our G-E furnaces turn out proves the importance of properly locating heating elements and designing the circulation equipment to fit the loads."

ALUMINUM FABRICATORS, as well as prime producers like Reynolds, can profit by using G-E furnaces for their heat-treating operations.

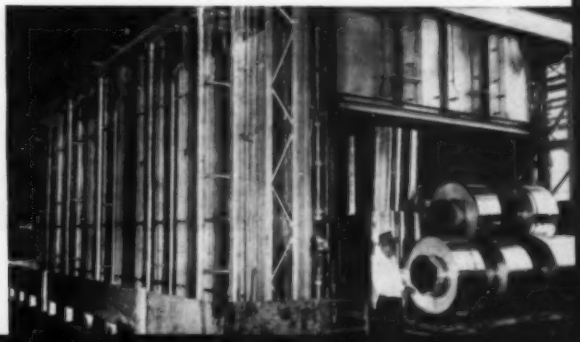
TAKE ADVANTAGE of G-E experience in heat-treating of aluminum. Call the nearest G-E sales office for the services and recommendations of their experienced Industrial Heating Specialist on your heat-treating problem. *General Electric Company, Schenectady, N.Y.* 720-82

GENERAL ELECTRIC

SEVEN DAYS A WEEK this roller-hearth furnace works around-the-clock to heat and spray-quench bars and rods at 950 F.



100 TONS PER CHARGE are annealed in this metal-lined truck furnace. Highest-quality stock results from uniform heating.



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Insurance for
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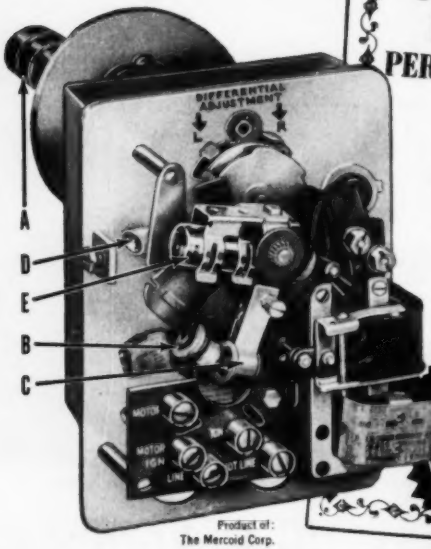

Product of:
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This precision built Mercoid JMI Pyratherm provides positive protection against flame or ignition failure of automatic oil burners. The Pyratherm, actuated by Chace Thermostatic Bimetal, insures having the ignition circuit closed before every starting operation of the burner. The safety mechanism operates on a closed circuit principle; opening of any circuit prevents burner operation until it has been returned to the normal starting position.

During normal operation, the rise in stack temperature will actuate bimetal coil "A" in the stack and cause heater coil "B" to move away from bimetal loop "C" and open ignition switch "D" Should ignition fail to occur when the burner is started, heater coil "B" remains within bimetal loop "C" as the stack temperature does not rise. The current flowing through coil "B" heats up the bimetal loop "C" and stops the burner after the predetermined time has elapsed for which the safety has been set. In the event of flame failure, the stack temperature lowers causing the heater coil "B" to move into bimetal loop "C" and after predetermined time, safety switch "E" releases and stops the burner.

If the actuating element of your new control device is thermostatic bimetal, Chace can furnish it completely fabricated, ready for assembly. Our 29 types of bimetal are available in strips, coils, random long lengths and welded or brazed sub-assemblies. Before proceeding with your next design, consult our application engineers, recognized authorities on temperature responsive devices, or write today for our new 32-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing condensed engineering data.

W. M. CHACE CO.
Thermostatic Bimetal
1626 BEARD AVE., DETROIT 9, MICH.

German Report on Welding in the U.S.

(Continued from p. 146)

tact" and other special types of electrodes are used very seldom and, in fact, are unknown in many places. Welding is usually carried out with alternating current, however, there are a few firms that prefer to use direct current.

2. Nearly all arc welding is carried out as shielded-arc welding. Automatic carbon-arc welding was found in only one establishment, and even here it was about to be replaced by the shielded-arc method. The semiautomatic shielded-arc process is also gaining in importance. The English "Fusarc" process is not used in the United States. However, we did see an American unit called a "fire cracker" which operated on the same principle.

3. Inert-gas-shielded arc welding processes are found to be growing rapidly in importance. The rapid progress of "Aircomatic" welding is particularly noteworthy. These processes, when used for joining light metals, copper alloys and such, produce superior weldments and very high welding speeds, and can also be used vertically.

4. The various electrical resistance welding processes, such as spot-seam and butt welding, find extensive application in American mass production. They are often used together with other joining processes.

Gas-flame methods are used mainly for flame cutting, brazing, spraying and flame hardening. Flame cutting (both manual and by machine) is used to a much greater extent than in Germany. Powder cutting is also widely used now. For mass production, furnace brazing with protective atmospheres is preferred over flame brazing. Metal spraying is used for the same purposes as in Germany. Nevertheless it is evident that the use of this process is not very widespread in the United States.

Welding processes such as thermit, water-gas, "Fesa-Weifel" and others were not encountered. In the field of structural welding, the Americans are obviously not as well advanced as the Germans, probably because there is not the same need to conserve material.

The extensive use of clamps and similar equipment is also worth noting. Heat treating after welding is much the same as in Germany, except that much larger parts are

(Continued on p. 150)

ENTHONE METAL STRIPPERS

No Attack on Base Metal...Fast Action

UPPER PHOTO
Highly polished sandwich grill cover. Right half stripped with Metal Stripper "A". Note smooth bright surface ready for replating. Small parts may be stripped by basket or bulk processes.

LOWER PHOTO
Silver soldered gun parts. Top shows work with excess solder formerly removed mechanically. Bottom shows part cleaned with Metal Stripper "A". Result: a cleaner part free of scratches at lower cost. Photo courtesy High Standard Mfg. Co., Hamden, Conn.

METAL STRIPPER "A" is an alkaline material used at room temperature to 180° F. for rapid stripping of nickel, copper, zinc, cadmium and silver. No attack on base steel.

METAL STRIPPER N-165 S is a neutral material that is added to acids for rapid dissolving of nickel, lead, tin, zinc and cadmium from copper base alloys.

Work is immersed in an acid solution containing 1 lb. per gallon of Metal Stripper N-165 S from 150-180° F. Acids used are sulphuric, hydrochloric, sulfamic and fluoboric acids. Rate of stripping is from 0.001" to 0.008" per hour.

ZINC STRIPPER is an alkaline material used in a steel tank that rapidly strips zinc from steel without current. Solid zinc, electroplated zinc and hot galvanized coatings are readily dissolved. Operating temperature is 200-210° F.

WRITE Enthone for advice and information on stripping of defective plated work and the selective dissolving of metals. Also ask for Enthone check list of 60 products for better metal finishing.

METAL FINISHING PROCESSES

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AMERICAN CHEMICAL PAINT COMPANY

AMBLER ACP PENNA.

Technical Service Data Sheet
Subject: INDEX OF ACP CHEMICALS FOR METAL PRESERVATION AND PAINT PROTECTION

METAL	OPERATION	ACP CHEMICAL
ALUMINUM	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Preparation for Painting	"ALODINE" "DURIDINE" "DEOXIDINE"
	Protection from Corrosion	"ALODINE"
BRASS	Brightening	"ACP BRIGHT DIP"
	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "CUPROTEK"
	Corrosion Prevention	"CUPROTEK"
	Soldering Flux	"FLOSOL"
COPPER, BERYLLIUM, AND COPPER ALLOYS	Brightening	"ACP BRIGHT DIP"
	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "CUPROTEK"
	Coating Steel with Copper	"CUPRODINE"
	Corrosion Prevention	"CUPROTEK"
	Scale Modification	"RIDOXINE"
	Soldering Flux	"FLOSOL"
	Stripping Copper Coatings	"ACP COPPER STRIPPING SOLUTION"
GALVANIZED IRON, ZINC, AND CADMIUM	Cleaning	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Corrosion Proofing	"ZINODINE"
	Paint Bonding	"ZINODINE"
	Phosphate Coating, in Preparation for Painting	"LITHOFORM"
	Soldering Flux	"FLOSOL"
IRON AND STEEL	Chromate Coating, in Preparation for Painting	"CROMODINE"
	Cleaning	"ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "DURIDINE"
	Coating with Copper	"CUPRODINE"
	Drawing and Extrusion	"GRANODRAW"
	Paint Bonding	"CROMODINE" "DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Paint Stripping	"CAUSTIC SODA AND SOLVENT NO. 3"
	Phosphate Coating, in Preparation for Painting	"DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Phosphate Coating, to Protect Friction Surfaces	"THERMOIL-GRANODINE"
	Pickling with Inhibited Acids	"RODINE"
	Rust Prevention for Unpainted Iron	"PEROLINE"
	Rust Proofing	"PERMADINE" "THERMOIL-GRANODINE"
	Rust Removal—Brush, Dip, or Spray	"DEOXIDINE"
	Soldering Flux	"FLOSOL"
MAGNESIUM	Cleaning	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Pickling	"RODINE (M-200)"
STAINLESS STEEL	Cleaning	"DEOXIDINE"
	Coating with Copper	"CUPRODINE"
	Pickle Polishing	"RODINE"
	Soldering Flux	"FLOSOL"

CHEMICALS ACP PROCESSES

WRITE FOR DESCRIPTIVE FOLDERS ON THE ABOVE CHEMICALS AND FOR INFORMATION ON YOUR OWN METAL PROTECTION PROBLEMS

CHEMICALS ACP PROCESSES

German Report on Welding in the U.S.

(Continued from p. 148)

stress-relieved. Furnaces of corresponding larger dimensions are used for this purpose.

The organization of welding operations varies widely among individual firms. Some firms meticulously design and test every welding job in the laboratory before actually going into mass production. The workshop then has detailed instructions in the form of welding plans. Inspectors are employed for the purpose of control. Usually these inspectors only examine the external appearance of the weldments. Radiographic examinations are only carried out on samples. Methods such as ultrasonic testing find little application.

It is remarkable that, on the average, the specifications allow substantially inferior appearance of the weldments. However, experience with these welds over a period of years has proved them to be satisfactory; there is no cause to be meticulous merely for the sake of appearance.

Many firms train their own welders. There exists considerable disagreement with respect to the length of training required, and the levels of that training. In general it appears that welders are qualified to do only one given job. A broad foundation of training, as is customary in Germany, is looked upon as superfluous and uneconomical in America.

PREDICTED DEVELOPMENTS

The authors feel that it may be somewhat rash to make predictions about future developments in welding in the U.S.A. However, they believe that certain trends are well established and a summary of their predictions follows:

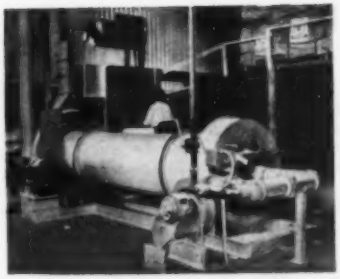
1. Welding technology will gain further application and in so doing the welding industry will expand. Certainly, welded bridge construction will be initiated.

2. Within welding technique itself, there will be a further increase in the use of automatic methods. In the inert-gas-shielded arc welding field, manual arc welding will be superseded to an increasing extent by shielded-arc welding.

3. Gas-shielded methods (such as Heliarc and Argon arc) will be just as far advanced as the Aircomatic method for the welding of

(Continued on p. 152)

←**WELDING INCONEL** feeder spirals to inner Inconel shell of a perlite expansion furnace. This shell, in which the mineral is pre-heated and then "popped" at temperatures ranging to 2000° F., is suspended only at the ends, and rotates constantly. Use of Inconel minimizes sagging, reduces crust formation, scaling and abrasion, and provides rapid heat transfer. →Furnace in operation, with raw ore being dropped into burner flame. *Illustrations by courtesy of The Perlite Corporation, Lansdowne, Pa.*



Improved High-Temperature Furnace

Boosts Production of the "CINDERELLA MINERAL"

Twelve years ago, it was commercially unknown.

Today, there's a demand for more than 18 million cubic feet a year. And the limit is nowhere in sight.

That's the Cinderella story of perlite, a glassy volcanic mineral found in the Rocky Mountains.

First used in place of sand as a concrete and plaster aggregate, perlite has now proved its value in many other fields. It is used in drilling muds and oil well cements... as a filler in plastics and resins... even as packing material for fragile merchandise.

In theory, the processing of perlite is fairly simple. You crush the mined or quarried ore (which is nearly 75% silica), and then heat it to a high temperature. Entrapped water vaporizes, and the ore pops like corn, expanding to 10 times its original volume.

There's the finished product! And many times, too, the processors of perlite also look at a "finished" furnace. For processing temperatures that sometimes exceed 2000° F. play hob with ceramic linings. Heating and cooling bring on spalling. Even the rough ore particles themselves do plenty of damage.

As production demands soared, a way had to be found to beat these furnace problems. And it was – with Inconel®, the high-temperature alloy so widely used in jet-engine combustion chambers and metal heat-treating equipment.

Long known as one of the most durable high-temperature metals, Inconel resists wear and abrasion. It helps protect product purity. It reduces clinker formation... scaling... buckling... corrosion. In perlite furnaces, Inconel promises a service life up to 5 times that of firebrick.

Right now, Inconel is on extended delivery because so much is needed for defense. But if you have any type of metal-failure problem, Inco's High-Temperature Engineers may be able to help you. Write us for your copy of the "High-Temperature Work Sheet," a simplified form on which to describe your problem. No obligation.

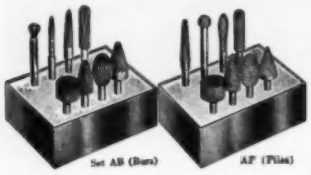
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

INCO TRADE MARK **INCONEL**... *for long life at high temperatures*

MARTINDALE

ROTARY BURS AND FILES

Made of high-speed steel. Produced in our own factory where uniform hardness is assured by heat-treating in electric furnaces on which the temperature is closely controlled by electric eyes.



Sets AB & AF	Per Set
1 set	$11.05 net
2 to 11 sets	9.75 net
12 or more	8.45 net

The above sets, with ¼" diameter shanks, are composed of the 8 most popular sizes for general use.

Over 200 sizes and shapes (total over 75,000 pieces) are carried in stock for immediate shipment.

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"MOTOR-FLEX" GRINDERS

These high-quality, portable flexible-shaft tools are made in 7 types for operation on bench, floor, or overhead.

Write for 64-page Catalog No. 28 covering above and many other products for maintenance, safety, and production.

MARTINDALE ELECTRIC CO.

1372 Hird Avenue, Cleveland 7, Ohio

German Report on Welding in the U.S.

(Continued from p. 150)

nonferrous metals and alloy steels.

4. The structural design and analysis of welded joints will be improved. Extensive research on this subject is being carried out under the Subcommittee on Structural Steel and Pressure Vessels of the Welding Research Council.

5. The standardization of materials, equipment, tests and designing methods will become more extensive.

6. Finally, welding techniques will progress rapidly in all fields, and advancements will be made in the production of welding machines and equipment, as well as the application of welding techniques.

USEFUL PRACTICES FOR GERMANY

In many respects the industry is on a different scale in Germany than in the U.S.A., so that newer American methods and developments cannot always be successfully transferred directly to German industry. Nevertheless some of these methods, such as gas-shielded welding, can be adopted in Germany.

Mass production does not exist in Germany on the same scale as in the U.S.A. This means that machines designed for one special job cannot be introduced; for example, spot welding machines for Germany must be of multipurpose design. Consequently, personnel in German plants must also be trained to be more versatile, and not as in the U.S.A., trained to do only one specific job. But, a greater use of welding machines and better over-all organization can be used by the German industry.

In the future, Germany will still be more noted for high quality, individual work than will the U.S.A. However, we can learn from the Americans that it is uneconomical to set higher specifications on quality and outer appearance than is required for the purpose.

REVIEWER'S COMMENTS

The scope and organization of this article is certainly worth mentioning. It is divided into 3 main divisions: *(a)* Noteworthy Details of Welding Methods, *(b)* The Application of Welding to Manufacturing, and *(c)* Research in Welding Technology.

(Continued on p. 154)

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MINERAL COMPANY
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PURE DUCTILE ZIRCONIUM

- Iodide processed Zirconium of highest purity for commercial use.
- 20% lighter than steel.
- outstanding resistance to corrosive attack by both acids and alkalies.
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Specify—
N·A·X
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... And
"MAKE YOUR PRODUCT LAST LONGER"

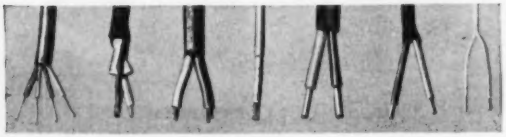
Containers and pressure vessels assure greater service when made of N-A-X HIGH-TENSILE steel. The durability of this low-alloy steel, its greater resistance to corrosion and abrasion, and its exceptional fabricating and welding qualities are important characteristics. The greater strength of N-A-X HIGH-TENSILE steel permits fabrication of containers from thinner sections — reducing costly deadweight to a minimum. If you are interested in effecting economies in barrels, drums or cylinders, investigate N-A-X HIGH-TENSILE steel.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division — Ecorse, Detroit 29, Mich.

NATIONAL STEEL CORPORATION

Thermo Electric Wires for Thermocouples Extensions



ACCURATE because the thermo elements for all wires are carefully matched for accurate calibration.

DURABLE because all insulating materials are carefully selected, applied and treated to give long service, even under abnormal conditions.

DEPENDABLE because the finished wires must meet *ALL* our high standards of accuracy and quality.

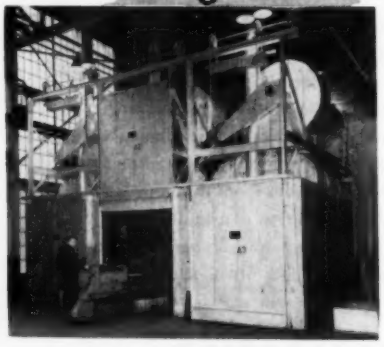
Thermo Electric Wires are made for all standard thermocouple calibrations and are insulated with the latest types of plastics, asbestos and fiberglass. The fibrous insulations are compound saturated for added protection against moisture and abrasion. For severe abrasive conditions, a metallic wire or ribbon is braided directly over the outer insulation.

MIL-W SPECIFICATIONS—Iron Constantan and Chromel Alumel Extension Wires are being insulated to meet MIL-W specifications.

For detailed specifications—write for Wire Bulletin 30H

Thermo Electric Co., Inc.
FAIR LAWN NEW JERSEY

CARL-MAYER AGING OVENS at Large Aluminum Co.



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The CARL-MAYER Corporation
3030 EUCLID AVE. · · · · CLEVELAND 15, OHIO

German Report on Welding in the U.S.

(Continued from p. 152)

The first section is divided into various subsections each dealing with a single phase of welding technology in which the American practice is described and then compared with the German.

The second section follows the same form except that organization, training and similar topics are dealt with. The third section is devoted to a listing of the various institutes sponsoring or carrying out research. Their organization, research projects, and in some instances, the number of people employed and the money spent, are mentioned.

This report covers every aspect of welding and is by no means limited to technology. For example, in the subsection dealing with electrode manufacture the authors discuss the organization and subdivision of the industry itself. In the section on the application of welding to manufacturing, the authors discuss industrial organization, wages, training and personnel classification.

R. C. SHNAY

Impregnation of Castings*

CORRECTION OF SEEPAGE or fine porosity in castings by impregnation has become a standard technique widely used and accepted throughout industry for sand and permanent mold castings, die castings, of both ferrous and nonferrous metals. The latter predominate because of their greater liability to porosity.

Four groups of materials comprise the usual impregnating compounds: *(a)* The sodium silicate type, either with or without metal powder flours or fillers; *(b)* linseed or tung oils, baked after impregnation; *(c)* resin and resin-oil combinations; and *(d)* the newer air-setting low-viscosity compounds. The last two are the most frequently used today.

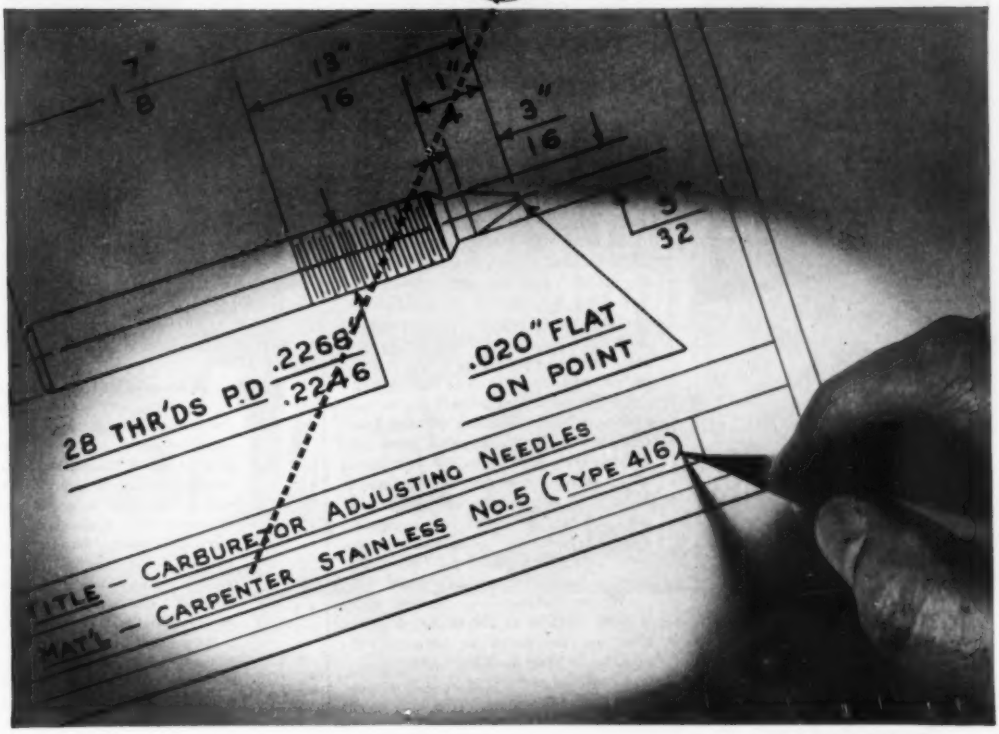
Five basic methods have been developed for the impregnation of castings, these are:

1. Immersion in the impregnant in a pressure-tight vessel to which pressure is applied, the oldest system

(Continued on p. 156)

*Abstract of "Vacuum Impregnation of Castings", by L. W. Hull, *Journal of Metals*, Vol. 4, January 1952, p. 30.

X MARKS THE SPOT



. . . Where You Can Start to Cut Stainless Fabricating Costs

You'll be surprised at the *difference* it makes when you write "Carpenter Stainless" on your prints. Right off the bat you have a *head start* in lowering rejects and increasing tool life. Here's why:

At the specialty Mill in Reading, Pa., where the first Free-Machining Stainless was born, we refuse to treat Stainless as a "commodity". With us it's a *specialty*—every bar is constantly inspected to remove the last fabricating headache. And this policy has really paid-off for plants like yours! Take this report for example:

"From now on, we will always keep enough Carpenter Stainless No. 5 on hand. When we recently switched to another Type 416 Stainless, speeds and feeds had to be reduced by 25%. Moreover, the threads were rough and rejects were piling up."

Job after job *proves* there *is* a difference in this Free-Machining Stainless. To discover just how much that difference can mean to *your* unit costs, contact Carpenter. Simply call your nearest Carpenter Mill-Branch Warehouse or Distributor.

Stainless Jobs are Easier (and More Profitable) when your men have accurate information on doing each job. Turning, drilling, reaming, etc., are all discussed in Carpenter's "Notebook on Machining Stainless Steels". If you would like a copy, write us a note on your company letterhead and indicate your title.

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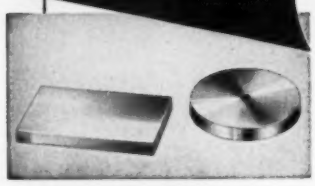

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Impregnation of Castings

(Continued from p. 154)

but one subject to air entrapment.

2. Internal pressure method by which large castings are sealed off except for a single port.

3. External pressure by batch immersion, for more economical treatment of smaller parts.

4. Vacuum impregnation by batch immersion, followed by pressure.

5. Vacuum connection to one port, with the sealant pulled through walls from outside to inside.

Methods 2 and 4 are preferred generally. Impregnation usually is done after machining, with the first step in the vacuum method being thorough cleaning and degreasing, followed by drying at mild heat. Vacuum is drawn to 29 in. or more, and held for 20 min. before admission of the impregnant.

Pressure is applied to the impregnant by introducing inert gas or air above it after shutting off the vacuum line. Conventionally, pressure is maintained at 60 to 100 psi. from 20 to 40 min. In one arrangement, 15 min. is allowed for each ¼ in. of depth to be penetrated, or the equivalent of ½ hr. for a maximum 1-in. section, recognizing that pressure applies equally from both sides.

Where baking is necessary, this is done usually at 250 to 300° F., the time varying from as little as 10 min. to as long as 5 hr. After cooling, castings are tested at 50% above working pressure.

A. H. ALLEN

High-Temperature Embrittlement of Straight Chromium Steels*

EMBRITTLEMENT of straight chromium stainless alloys due to the 885° F. brittleness and to sigma phase formation has been known and discussed for years. The author describes a third form of embrittlement which occurs when these alloys are heated to a temperature over 2100° F. (exact temperature depends on the alloy) and rapidly cooled as in the as-welded or as-cast condition. This embrittlement has previously been ascribed to the extremely coarse grain resulting from such heat treatment.

Whether or not an alloy is sus-

(Continued on p. 158)

*Abstract of "High-Temperature Embrittlement in Chromium-Iron Alloys Containing 12-16% Chromium", by Helmut Thielsch, *Metallurgia*, Vol. 44, November 1951, p. 220-226.

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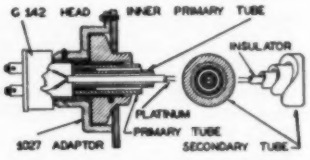

into a complete thermocouple assembly is light in weight and permits easy replacement of new elements into a protecting tube assembly.

The Gordon Policy—highest quality and standards of material — plus Gordon craftsmanship at the lowest possible price.

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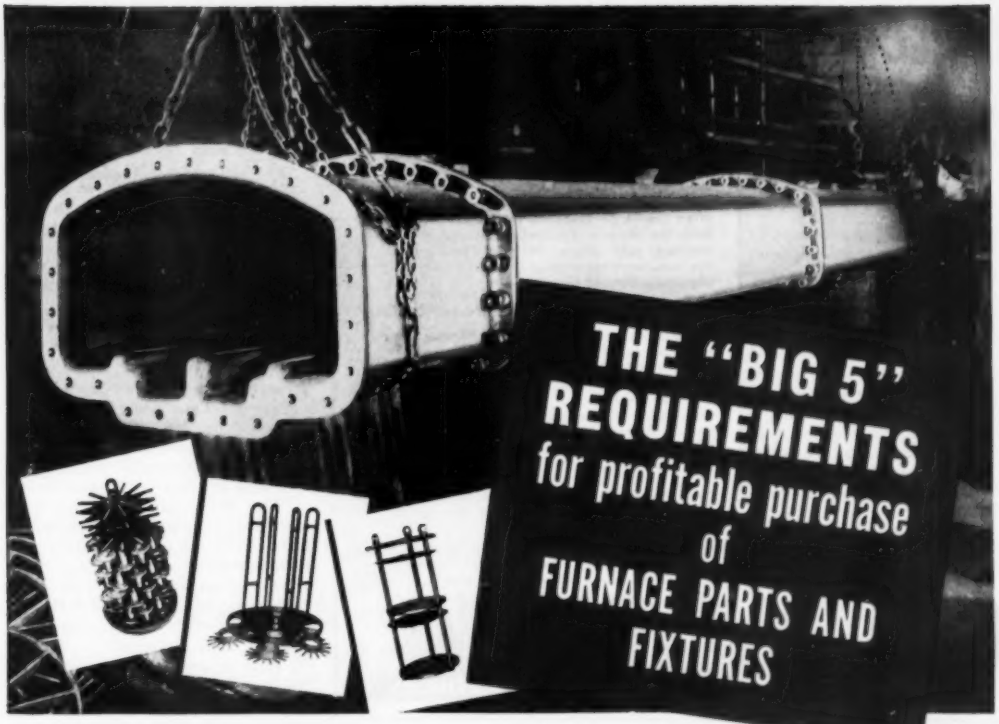

Here are the five big considerations that will assure you the most profitable purchasing of furnace parts and fixtures. In meeting the requirements they embody, Driver-Harris offers advantages unequalled by any other source of supply.

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The high heat- and corrosion-resistant cast alloys Nichrome®, Chromax®, and Cimet®—developed exclusively by Driver-Harris—furnish heat-treating equipment that is unexcelled for *efficiency* and *long life*.

2. QUALITY OF CASTINGS

Driver-Harris brings over 40 years of alloy-casting experience to the production of heat-treating equipment for all types of furnaces. D-H muffles, retorts, and furnace fixtures cast from Nichrome and Chromax are today compiling outstanding service records thruout the heat-treating industry.

3. LOW HEAT-HOUR COSTS

The top grade nickel-chrome alloys supplied by Driver-Harris provide furnace parts and fixtures that deliver *more hours of service per buyer's dollar*. Such equipment, assuring lower heat-hour costs, is not only most economical in the long run, but the most economical to purchase initially.

4. SUPPLIER'S SERVICE AND CONSULTATION FACILITIES

Driver-Harris has representatives thruout the United States, and in Canada. The service requirements of its customers receive prompt attention, and sound technical advice is always available, without obligation, to help users of D-H equipment solve their heat-treating problems.

5. SUPPLIER'S STOCKPILE OF EXPERIENCE IN THE HEAT-TREATING FIELD

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Work to be precleaned is dipped into (or sprayed with) the Magnusol cleaning solution . . . made up of Magnusol concentrate and kerosene or safety solvent. The solution rapidly wets and penetrates the dirt on the work, loosening it so that it is completely flushed off when the work is rinsed with water, steam or safety solvent. Not only oil and grease, but all solid dirts, including metal particles, are removed.

For complete information, write for Bulletin 30.

Ordinary degreasing methods remove the oils and greases that are soluble in the solvents used, along with part of the solid dirts. But all these solids are not removed . . . and trouble often results on the final cleaning operation. With the Magnus Emulso-Dip method of precleaning, solid dirts as well as oils and greases are completely removed, giving you a thoroughly physically cleaned surface.

But Keep Costs and Maintenance Low

The Magnus Emulso-Dip method of precleaning employs readily available petroleum solvents and the equally available Magnusol concentrate. Together they make up a low cost cleaning solution that works fast and cleans thoroughly. The solution is safe for personnel and for all metals. It does not tend to decompose and cause corrosion of equipment and surrounding apparatus.

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High-Temperature Embrittlement

(Continued from p. 156)

ceptible to the high-temperature embrittlement depends on the alloy content which determines the austenite-ferrite balance at elevated temperatures. The author shows a gamma loop plotted according to chromium equivalent [Cr + 10 (Al − 0.02) + 2.5 Si]. (The loop is closed at a maximum chromium equivalent of about 12%, with a ferrite plus austenite field extending to about 16%. The mixed field probably extends to a somewhat greater percentage because high-chromium Type 430 and low-chromium Type 446 with chromium equivalents appreciably above 16% will have substantial amounts of austenite at elevated temperatures.)

The investigation consisted of tensile tests, Charpy notch-impact tests, hardness measurements and metallographic examination made after various heat treatments. Sections from Type 410 with 0.11% C, Type 410 with 0.067% C, Types 405 and 430 were included.

Heat treatment consisted of water quenching from temperatures of 1500 to 2500° F. Hardness curves were plotted against quench temperature; these showed that in all alloys, except the high-carbon Type 410, hardness after quenching approaches a maximum between 1700 and 1900° F., drops to a minimum in the 2100 to 2400° F. range and rises again at quench temperatures exceeding 2400° F. The Type 410 quenched from about 1800° F. shows maximum hardness. At increasing quench temperatures up to 2500° F. this hardness gradually decreases, but without showing the pronounced dip in the 2100 to 2400° F. range experienced by the other alloys. This is considered due to incomplete solution of austenite at high temperatures.

The first maximum corresponds to the most nearly fully austenitic temperature. The decreasing hardnesses which follow with higher quench temperatures are caused by increasing amounts of high-temperature ferrite. The increasing hardness at the highest quench temperatures is caused by carbide solution in high-temperature or delta-ferrite. It is the embrittlement resulting from this high-temperature treatment the author describes.

The author shows by Charpy impact tests that it is possible to remove the effect of this embrittle-

(Continued on p. 160)

The burner block is the heart of your fuel-fired furnace

TASIL Burner Block installed in a No. 225-4 Dual Fuel Burner of the North American Manufacturing Co., Cleveland, Ohio, leading producers of industrial fuel-burning equipment. TASIL Burner Blocks are standard equipment on North American burners for high temperature applications.

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PRE-FIRED BURNER BLOCKS of Taylor Sillimanite (TASIL) are preferred by North American and a majority of leading furnace and burner manufacturers for high temperature applications. TASIL is specified because the block must hold original contour and dimensions. Compared to blocks made of fireclay or most other refractory materials, TASIL has superior resistance to shrinkage, cracking or spalling. TASIL further qualifies because it is inert in either oxidizing or reducing atmospheres; has higher fusion point and resistance to corrosion by most industrial slags. For longer service from your heating, annealing or forging furnaces, specify TASIL burner blocks.

In an emergency, when a burner block failure occurs at the time your stocks of pre-fired shapes are depleted, you can ram your own TASIL Burner Blocks, on the job, with one of several TASIL Ramming Mixes *engineered* for this application. Burner Blocks which may be cast or poured in molds, air dried and placed in service can also be made from TASIL Hydrocast—the hydraulic-setting castable for use to 3000° F. Data on TASIL Ramming Mixes are given in Bulletin No. 315 . . . on TASIL Hydrocast, Bulletin No. 313. Write direct, or contact your Taylor field representative, for your free copies.

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High-Temperature Embrittlement

(Continued from p. 158)

ment by annealing at an intermediate temperature (1350° F.) after the 2500° F. treatment. Since this treatment results in a Widmanstätten pattern of carbide precipitation within the grains but does not affect the grain size, it is concluded that the embrittlement is due to high-temperature carbide solution in ferrite and not to the attendant excessive grain size. Two possible explanations for the mechanism are given: First, a possible segregation of carbon atoms in the lattice; and second, possible austenite formation in these high-carbon planes which changes to martensite in cooling and causes embrittlement.

R. A. Huseby

Nitride Crucibles*

From a survey of the physical properties and stabilities of refractory nitrides, the following were selected for production of experimental crucibles: titanium nitride, zirconium nitride, boron nitride, thorium nitride, lanthanum nitride, cerium nitride, uranium nitride, tantalum nitride, and vanadium nitride.

After preliminary experiments, greatest emphasis was placed on titanium and zirconium nitrides. These materials were manufactured from their respective hydrides under a subcontract by the Pigments Department of the E. I. duPont de Nemours and Co., Newport, Del.

A charge of the hydride (10 to 12 lb.) was spread over the middle portion of a large silicon reactor and heated at about 1000° C. for nearly 100 hr. in a stream of refrigerant-grade ammonia. The nitrogen content of the products reached as high as 90 to 95% of the theoretical value required by the respective formulas, TiN and ZrN.

Boron nitride of very high purity was purchased from the research laboratories of the General Electric Co. The remaining nitrides, including beryllium nitride (Be_3N_2) which

(Continued on p. 162)

*Abstract of AEC declassified report AECD-2942, "Preparation of Crucibles From Nitrides", by L. S. Foster. Based on Report MIT-1041 written at Massachusetts Institute of Technology, July 1945 (declassified March 23, 1950). Available from Office of Technical Services, Department of Commerce, Washington 25, D. C. (25¢).

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TYPE B HIGH PRECISION POTENTIOMETER

...a general purpose potentiometer with a number of notable refinements, suiting it particularly to thermocouple work. Distinctive features include:

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- Three reading dials—effective scale length of approximately 175 feet for each range.
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- Special provisions to minimize parasitic thermal emf's—including automatic compensation of slidewire thermals and gold contacts in galvanometer key.
- Exceptional convenience in reading and adjustment.
- Solid and substantial construction for many years of trouble-free service.

This standard laboratory potentiometer is also well suited for meter calibration, for checking portable potentiometers, and for other critical measurements of D.C. potentials requiring exceptionally high accuracy.

Described in Bulletin 270

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- Multiple-reflection optical system
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- For null or deflection measurements

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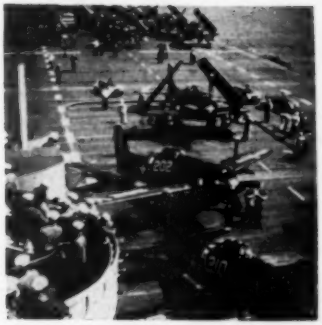


It's Nice to Know . . .

WE IN New England share our beaches, our summer playgrounds, our lakes and mountains with all America. Americans enjoy weekend play and lush vacations. Migrant millions travel our nation, and abroad, in quest of health, sport and fun. This is of the *essence* of FREEDOM.

Here, also, are the sinews and talons of Freedom. Great schools of science and management training free men to lead the advance of a new generation through advanced technology and teamwork. Great industries, rich in the tradition of three centuries of progress, accelerate Yankee ingenuity through applied research and unsurpassed craftsmanship. Their jet engines, electronics, precision tools, miracle drugs and myriad manufacture provide the base and core of Freedom,—STRENGTH.

Close to our playgrounds of Cape, Mountain, and Sound nest the "talons" of our U. S. A. F. fighter squadrons. Alerted by radar sentinels, vigilant the-clock-around, fighting Airmen stand guard while we work and play.

On the turbulent bosom of the broad Atlantic, and above and below, moves the U. S. Navy, our first line of defense. Vice Admiral John Ballentine, Commander Air Force, Atlantic Fleet, wields mighty whips with a hundred *fire tipped* lashes: those swiftly mobile nests of fighting hornets, our Naval Aircraft Carriers.

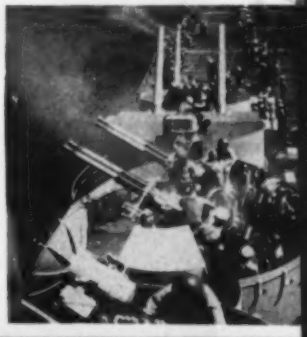
SET!

THE Carrier is one of few weapons in which the U. S. holds undisputed supremacy. Our modern Capital Ship, she is a prime instrument of diplomacy and world stability. She can operate without a base thousands of miles from home, showing our flag to firm the will of millions who cling to freedom in the shadow of darkness. She can bring effective force to bear with stark surprise at almost any stragetic point on the globe. Warned by her powerful radar and bristling with anti-aircraft batteries, she is the hottest target and the hardest to find. Her planes can deliver the Atomic Bomb.

NEW and bigger carriers are on the ways. The new 60,000-ton carrier, "Forrestal", will honor a GREAT AMERICAN. A list of his detractors is a roster of Reds, rats and dullards. It is rumored that the keel deck "Head" on the "FORRESTAL" will be dedicated to Louis Johnson, if, and when, some "Judas compromise" of the politically-connived steel strike permits its completion.

GO!

VACATIONS we need, with even a *modicum* of monkey-business, *on our own time*. There is, quite clearly, too much monkey-business, and *worse*, extending from the White House to the work bench and school room, wasting irretrievable time and vital substance. It has delayed, or aborted, Defense Production effort, now limping badly. All of us in A.S.M. can point it out in *profusion*. Human frailties and venimlity are such that, entirely apart from personalities and political credo, no one gang, or party, should continue too long in power. From our, perhaps prejudiced, viewpoint, 20 years is long enough,—in fact, we think it is *too damn long!*



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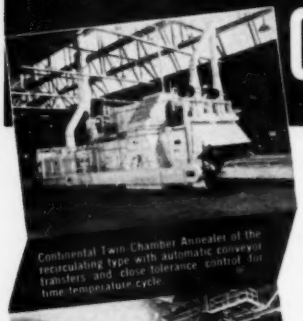
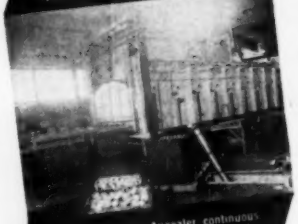


Continental Twin Chamber Annealer of the recirculating type with automatic conveyor transfers and close tolerance control for time-temperature cycle.

Two Continental Continuous Controlled Atmosphere Annealers, roller rail type, complete with transfer cars and conveyor systems.



Continental Stamping Annealer, continuous roller rail type, complete with baskets, handling conveyors, and automatic controls for work handling and temperature cycles.

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Nitride Crucibles

(Continued from p. 160)

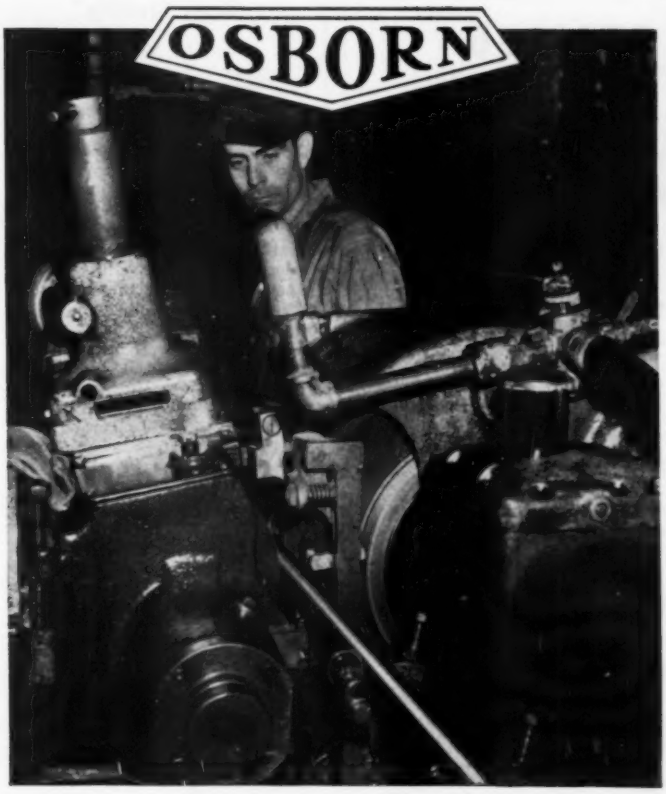
was made for another purpose, were produced by the metallurgical laboratory of the Massachusetts Institute of Technology. Methods for preparing them are given in the report.

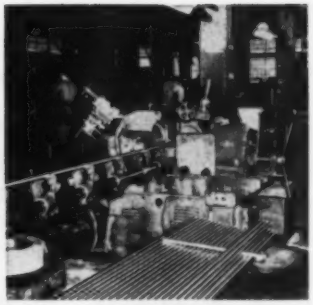
To produce crucibles, conventional ceramic techniques were followed. The powders were ball-milled, pressed, either in hydraulic steel molds or by hydrostatic pressure, fired in vacuum or an ammonia atmosphere in small induction furnaces, and tested for porosity and for attack by molten metals such as iron, cerium, or beryllium.

To produce nonporous crucibles of titanium nitride, it was found advantageous to add small percentages of titanium dioxide. Crucibles thus produced possessed a beautiful, golden, metallic luster, and a smooth, nonporous surface. With zirconium nitride, it was possible to produce nonporous crucibles without addition of oxide. These crucibles had a greenish silver, metallic luster. Since these nitrides are excellent conductors of electricity, they may be heated to incandescence in a vacuum by induction. By this means, various metals were melted in them to observe attack. No nitride crucible was found in which it was possible to melt beryllium without serious attack. On the other hand, iron could be melted in all of them, without apparent contamination. Boron nitride (a nonconductor of electricity) was outstandingly good for melting iron, which does not wet it, but has limited application because of its inherent lack of mechanical strength. Molten cerium did not attack zirconium nitride, titanium nitride or thorium nitride. It appeared to wet and become contaminated by boron nitride. In spite of the extensive research program that is reported, no unique applications for nitride crucibles were uncovered, except possibly for boron nitride. Boron nitride is being made commercially by the Norton Co.

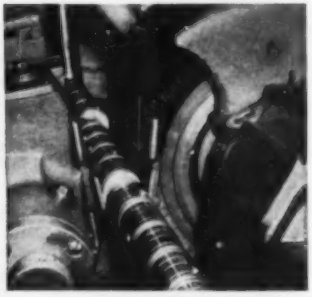
In addition to methods used for the preparation of nitrides, the report gives detailed information on methods used for comminution, pressing lubricants, design of molds for hydraulic pressing, design of molds for hydrostatic pressing, design of laboratory induction vacuum furnaces and induction furnaces having a protective atmosphere of ammonia, and on the effects of parameters on the porosity and other characteristics of the fired ware.

L. S. FOSTER





THE SET-UP. This shows the centerless grinding machine which also serves as a "centerless brusher". These pump rods vary from 1⅛ in. to 1½ in. diameter . . . from 6 ft. to 36 ft. in length. Regulating wheel speed is 52 r.p.m.



ANOTHER JOB. Here Centerless Brushing finishes cast iron pistons to micro-smoothness. Simplifies assembly operations and increases life of pistons and cylinders. Output of this machine is 10,000 pieces per 8 hours.

Finer finish . . . longer product life with Centerless Brushing

This machine does double duty. For removal of metal to close tolerance, it is a *centerless grinder.* Then, for finishing the surface to micro-smoothness it is a *centerless brusher.* Its conversion takes only a few minutes.

In the operation shown above, nickel-moly steel rods for pumps, are being finished by an Osborn Fascut Brush. Prior to brushing, the same machine with a grinding wheel in place of the brush made a rough grind, taking off .006 inch, and a finish grind, taking off .002 inch. Results of the Centerless Brushing: Produces a smoother finish. Reduces wear in pump packing. Reduces corrosive action on rods; makes them last longer.

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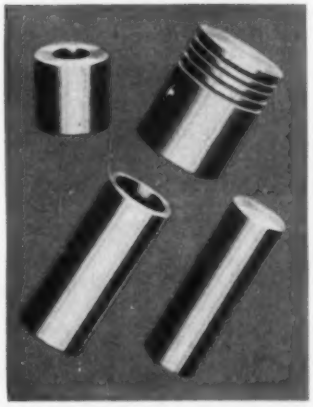
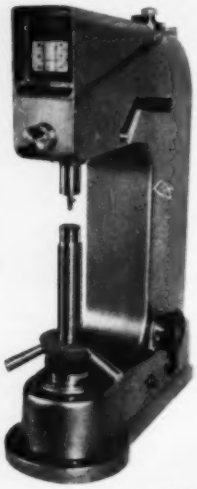


TYPICAL PARTS which are being improved by Centerless Brushing include pistons, piston pins, bushings, tubing . . . any cylindrical parts. It can be applied to many sizes of parts and types of material on a mass production basis.



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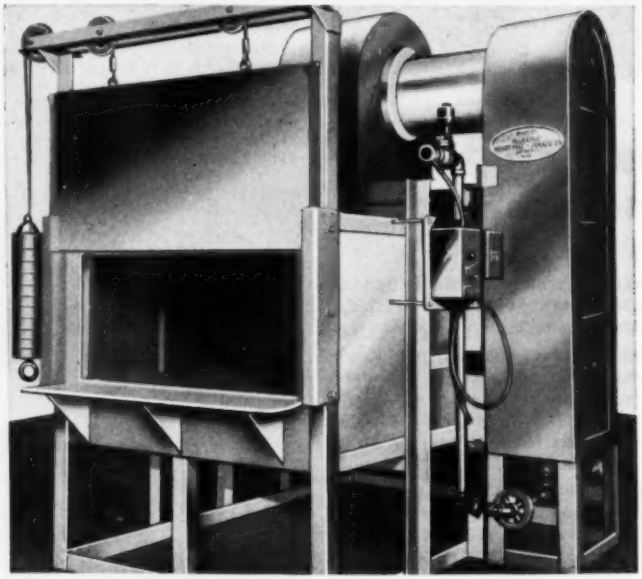


Batch type furnace for the heat treating of aluminum alloys—consists of atmosphere type burner mounted on the lower end of the duct which is for recirculating the air back into the furnace. Garden City high temperature fan is standard equipment for recirculating the heated air. This method of heating holds temperature with little or no variation. Mounting the burner in the duct, eliminates the necessity of an extra heating unit. . . .Send us your heat treating problems . . . our engineers will make a proposal without obligation.

Bellevue **INDUSTRIAL FURNACE COMPANY**

2626 Crane **Est. 1910** **Detroit 14, Michigan**

Steel "Quality"

(Continued from p. 108)

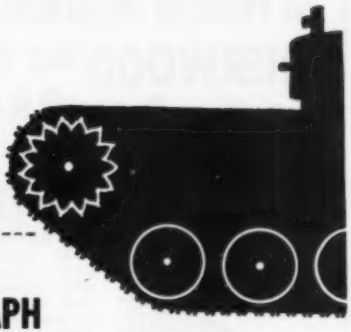
started, and these will give the old-time plants something to work on when competition rules again.

It has been my observation that the steel mills which show the best return on the dollar invested and on the tonnage melted are not the great, fully integrated mills with every resource available, but the semi-integrated mills with the most modern *finishing* facilities. This would indicate that the first equipment to modernize is at the finishing end. It is also worthy of note by our financiers that one of the steel companies showing the best net income for several years, measured as percentage of investment, has been producing carbon steel wire and nail stock from electric furnace ingots.

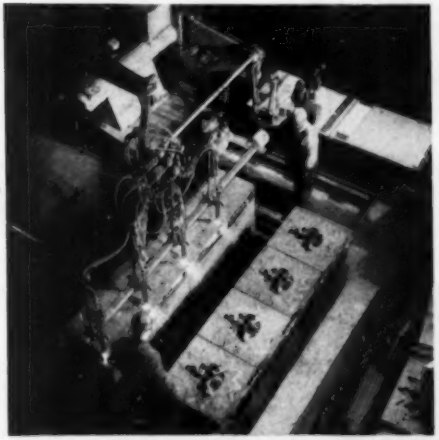
While the steel industry has made a remarkable production record during the past decade, the technical developments have been nothing remarkable. However, this is usually the case in times of high production and good returns which tend to cultivate a highly developed sense of self-satisfaction and contentment in the minds of management; this is not conducive to upsetting and sometimes irritating developments. Consequently, the real advances in the art come from smaller companies which are themselves just developing and are motivated by an intense desire to get into a competitive position with the well-entrenched and established producers.

It is my opinion that — in the possibly hectic, more competitive days to come — we will see the single-slag electric furnace heat replace almost entirely openhearth metal in the production of all alloy and special carbon steels. We shall see a development in hydrogen-reduced magnetite concentrates which will give the electric furnace the ability to make (with a fast, single-slag practice) very low sulphur steel of the very highest quality, comparable to any melted in the Swedish acid openhearth. We shall see the working out of a continuous casting process which will give the small electric furnace plant a relatively low-cost method of moving directly from the ladle to the billet. I think we will see a change in the location of alloy electric furnace steel plants to overcome transportation handicaps, with the possibility that electric furnace steel producing plants will be erected close to every important center of steel consumption.

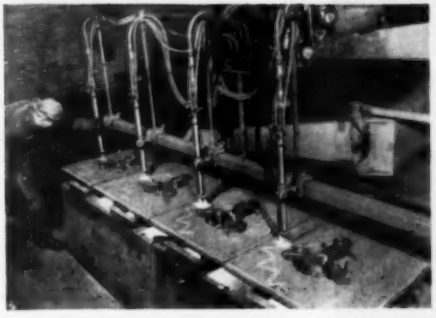
64 sprockets per day



AIRCO FOUR-TORCH TRAVOGRAPH CUTS FINISHED SPROCKETS!



The No. 50 Travograph in action. Inner circle and straight line cuts are done on rear table. The Electronic Tracer guides the arm movements automatically by following a low-cost outline drawing.



Outside pattern cut in progress on front table. Smooth, sharp-edged cuts make finish grinding unnecessary.

How to turn out tank sprockets to fit defense demands was quickly solved by the Otis Elevator Company. Installation of an electronically-guided Airco No. 50 Travograph Gas Cutting Machine in their Yonkers, New York plant was the answer.

Located next to the steel plate delivery entrance, Otis workers make quick work set-ups on their No. 50 Travograph, set a low-cost outline drawing under the Travograph's electronic tracer, and let the pantagraph arms guide the torches to work completion.

Torches are equipped with solenoid valves, operated by means of remote control switch which shuts gas off at work completion preventing contour-destroying notches . . . losing only torch gas — keeping hose lines full and instantly ready for next operation.

For your next production-run, large-parts job, where a machine-free finish is required on parts of any shape, it will pay you to consider the No. 50 Travograph. Whether you're cutting from plates, slabs, billets, or forgings, here is a precision machine that will cut identical parts on a profitable, quantity-production basis.

To obtain details about the Airco No. 50 Travograph for your operations, contact your nearest Airco office. Or just write and ask for Catalog 7, The No. 50 Travograph Gas Cutting Machine. Address: Advertising Department, 60 East 42nd Street, New York 17, New York.

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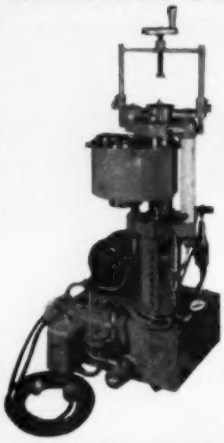
SHERWOOD WAX INJECTION PRESS

MODEL WP 12



This is the wax injection press which is "doing the job" of producing wax patterns for investment castings. Widely used in foundries of all sizes; several have 2 or more units, also installed in many government arsenals.

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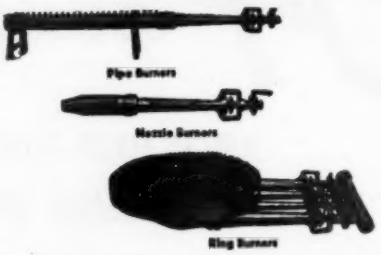

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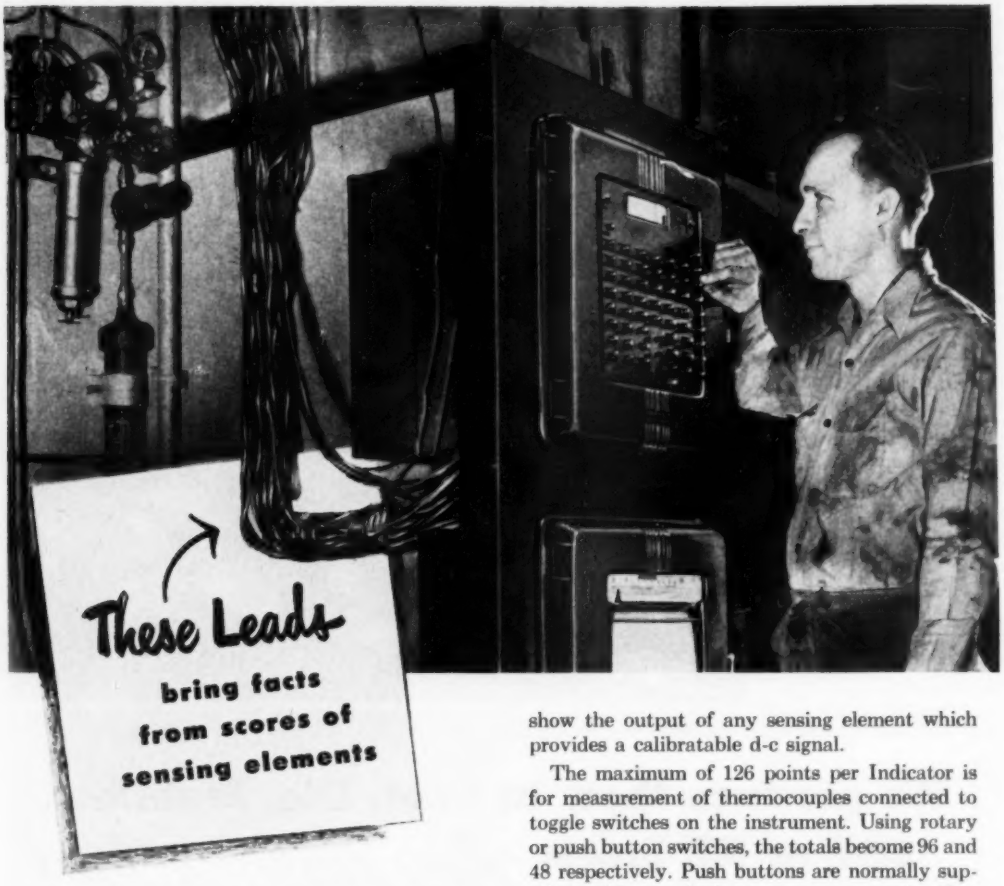

The scientist or test engineer who has a Speedomax Model G Electronic Indicator at his disposal is ready to save himself a lot of time and energy in running tests at as many as 126 different locations.

A flick of the finger connects the desired sensing element to the Indicator . . . the instrument's calibrated drum whirls to the reading . . . the drum stops dead still. The entire operation takes only 4½ seconds for consecutive readings at opposite ends of the scale. Minimum time for close-together points is only a fraction of a second. Logging speed depends only on the operator.

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The condition most frequently measured with these Indicators is temperature, with stress and strain a close second. However, many other quantities suggest themselves, since the Indicator can show the output of any sensing element which provides a calibratable d-c signal.

The maximum of 126 points per Indicator is for measurement of thermocouples connected to toggle switches on the instrument. Using rotary or push button switches, the totals become 96 and 48 respectively. Push buttons are normally supplied with interlocks to assure one-at-a-time operation, but when desired the interlocks can be disconnected so that several switches may be closed simultaneously, causing the instrument to give the average of those points.

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The equipment is described in our Catalog ND46(1). Whether or not you require this information at present, we will be glad to send a copy for reference. Address our nearest office, or 4927 Stenton Ave., Philadelphia 44, Pa.

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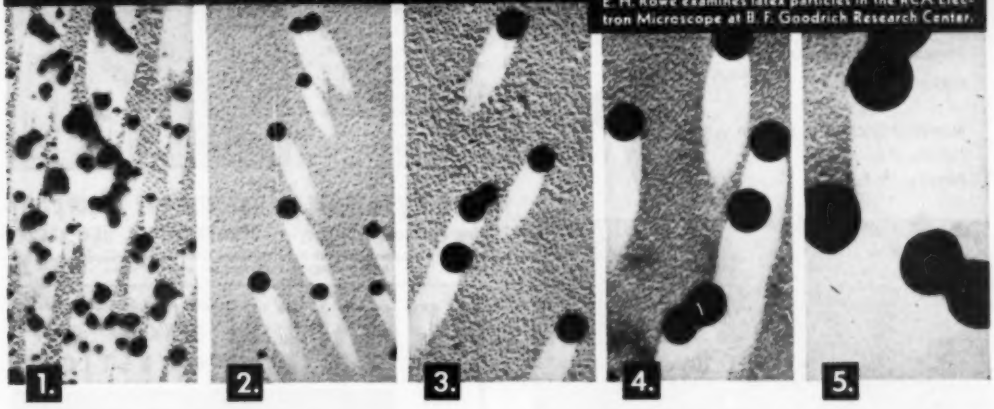
How the RCA *electron microscope* helps B. F. Goodrich make better latex rubber

E. H. Rowe examines latex particles in the RCA Electron Microscope at B. F. Goodrich Research Center.

These 5 RCA Electron Microscope micrographs (magnified 27,000 X) show the 5 successive polymerizations made by B. F. Goodrich to study effect of emulsifier on latex particles. (Note shadows caused by deposit of uranium.)



PROBLEM: to maintain *just the right amount* of emulsifier in a synthetic polymer latex. Particle size and stability of the latex depend on how much emulsifier is present. *Too much* starts new particles forming. *Too little* causes premature flocculation of the latex.

SOLUTION: Latex particles, shadowed with uranium, were studied in the RCA Electron Microscope. Five polymerizations were made; using the particles in the first for the seed of the second, and so on. From this study, engineers could determine just the right amount of emulsifier. Result: *better* control and *better* product.

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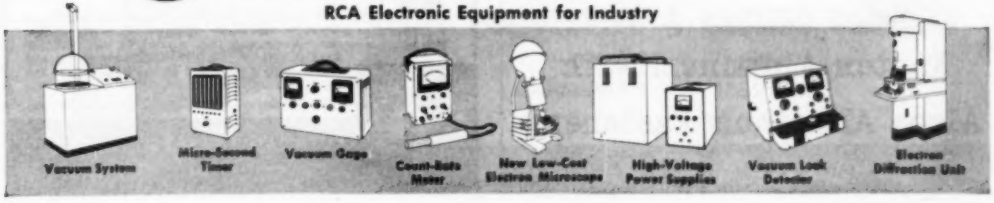

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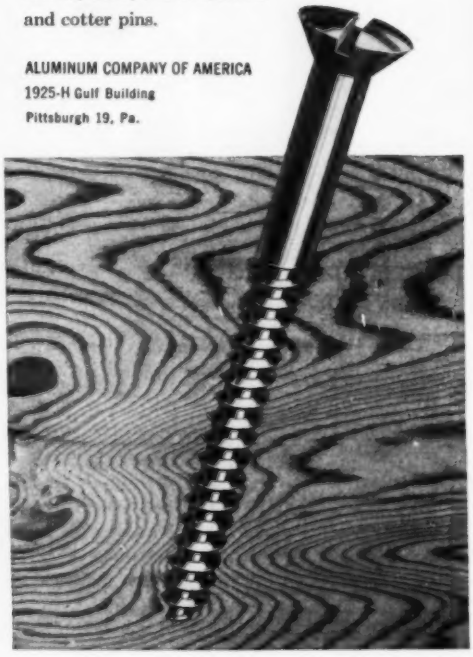

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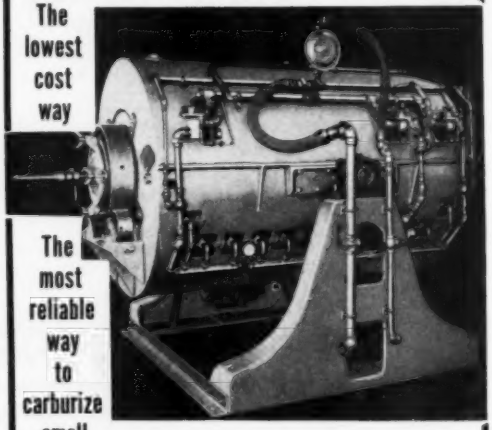

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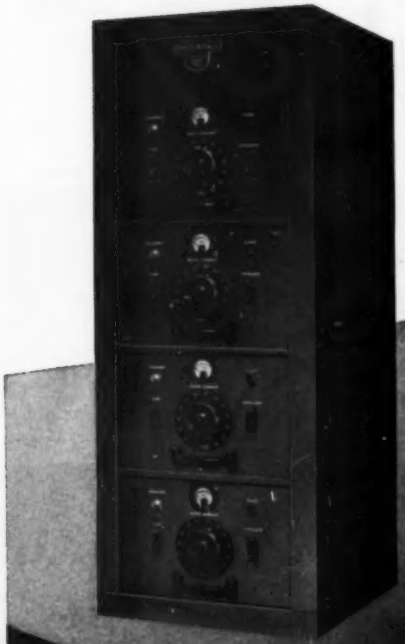

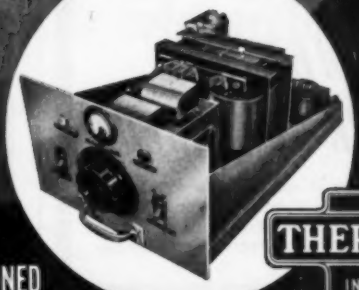

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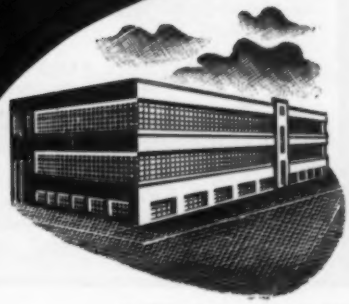

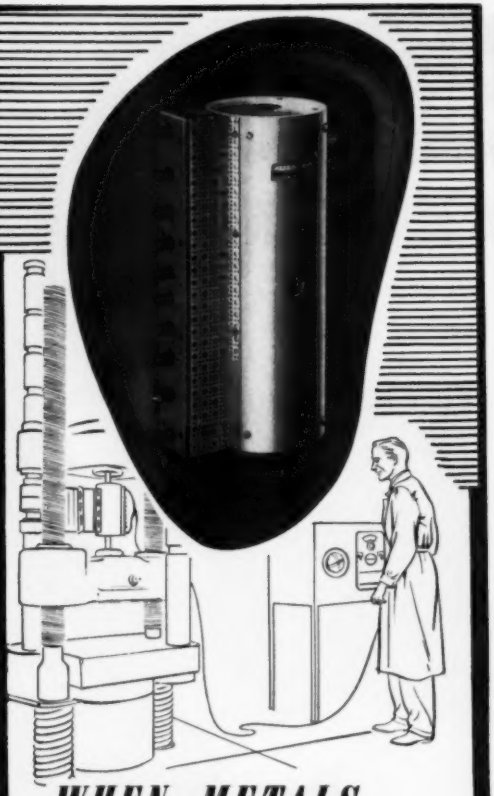

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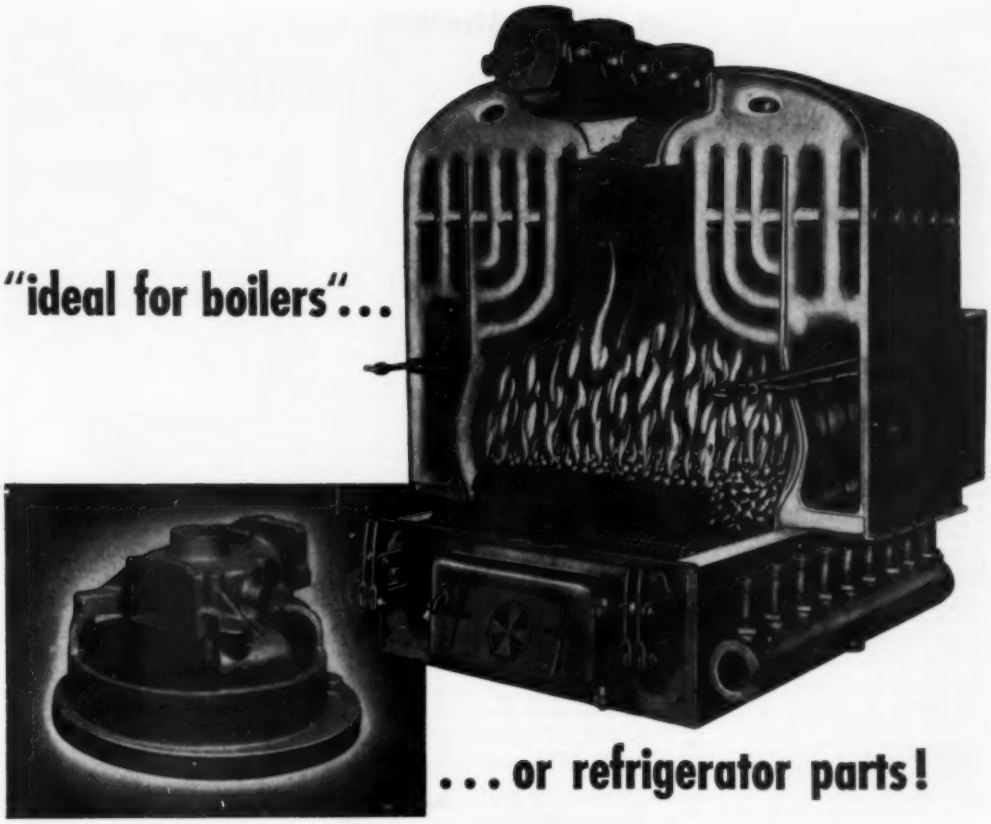

...or refrigerator parts!

take advantage of the versatility of GRAY IRON!

"GRAY IRON IS IDEAL FOR BOILER CONSTRUCTION", says the manufacturer of this boiler, "because it resists to the greatest possible extent the numerous corrosive factors that attack boilers both internally and externally. Furthermore, many boilers receive indifferent or poor care. Consequently, a very durable material is necessary for their construction."

WHERE RESISTANCE TO HEAT, CORROSION, WEAR AND VIBRATION is required—for boilers or refrigerator parts—gray iron provides it, at an economical cost. For example, this manufacturer reports gray iron boilers that are still in service after 67 years, without major repairs.

SO CONSIDER GRAY IRON whenever you need a part that must be durable under adverse operating conditions—that's either plain or intricately shaped—gray iron provides a wide strength range, is easily castable and readily machinable. You'll find all these advantages in gray iron castings.

Make It Better with Gray Iron

Second largest industry in the metal-working field

SCRAP IS NEEDED FOR DEFENSE—KEEP IT MOVING!

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO

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IMPORTANT NOTICE . . . . . .

The American Society for Metals will hold a confidential meeting on the subject of

"Refractory-Type Materials for High-Temperature Applications"

NOV. 24-25
1952
(Two days and one evening)
Hotel Carter
Cleveland • Ohio

THESE meetings will provide an opportunity for presentation and discussion of classified information that qualified members and guests need to know in the performance of their jobs and in the best interest of national defense.

Security regulations require that attendance be limited (between 400 and 500) to those who possess clearance papers through the Air Force, Navy, Research and Development Board, Atomic Energy, or other accredited U. S. agencies.

This meeting is not confined to ASM members but to all who qualify.

If you wish to secure clearance, send a request today for (1) clearance forms, (2) program of the meeting, (3) hotel reservation information, to the attention of →

RAY T. BAYLESS
American Society for Metals
7301 Euclid Avenue
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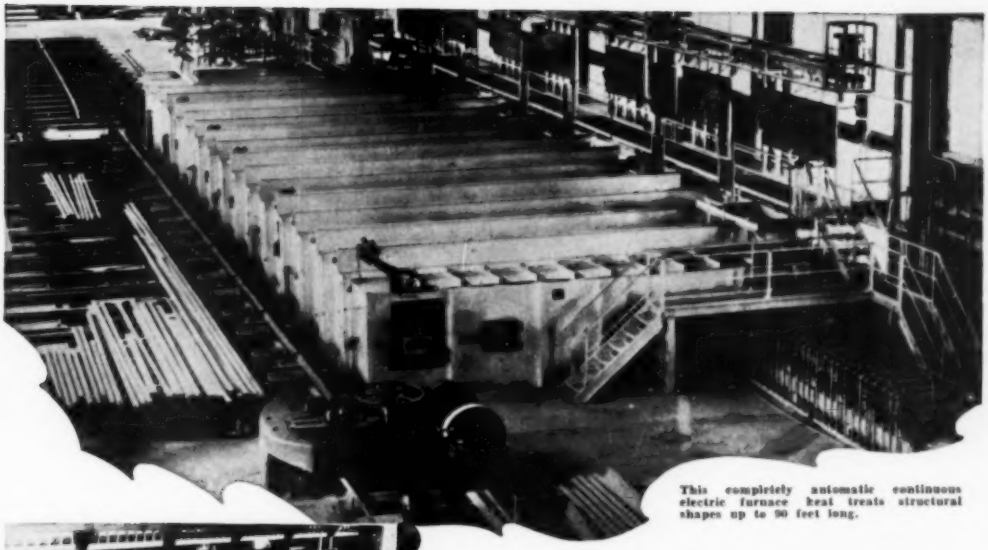
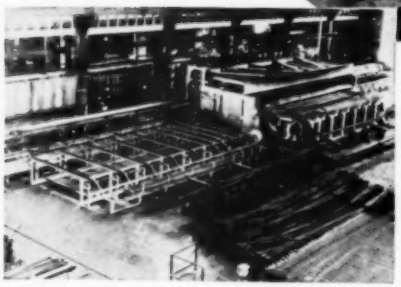


This completely automatic continuous electric furnace heat treats structural shapes up to 90 feet long.



An EF gas fired heat treating furnace, quenching machine and rod straightener—handles rods up to 30 ft. in length, continuously.

A large capacity EF continuous strip normalizing, annealing and galvanizing unit. This combination gas fired radiant tube and electrically heated installation is over 400 feet long.

93 ft. Long x 26 ft. Wide Maintains Temperature ±5°

Because of its great number of successful, large and unusual furnace installations The Electric Furnace Co. has justly earned an enviable reputation for solving difficult production furnace problems.

The furnaces shown are typical examples — the large aluminum furnace above is completely automatic — large structural shapes up to 90 ft. in length are automatically charged into the furnace, carried across the heating chamber and discharged through a spray quench — everything is automatic.

The heating chamber is 93 ft. long by 26 ft. wide. Despite its unusual size it maintains a uniform temperature throughout the entire heating chamber.

The furnace shown above, at left, is another outstanding installation—this equipment heats, quenches and straightens rods up to 30 ft. in length and was the first successful continuous furnace of this type built for this process. Several somewhat similar installations have since been made.

The view at left shows one of several large capacity continuous units we have built for processing ferrous and non-ferrous strip.

Other outstanding production furnace installations include furnaces for bright annealing both ferrous and non-ferrous strip, wire, tubing and other products ...furnaces for the production heat treatment of tank armor castings, cartridge cases, shell forgings, bomb and gun parts, machine gun cartridge clips, aircraft and aircraft engine parts, aluminum and magnesium castings, bolts, springs, and many other products.

If you have a difficult production furnace problem put it up to our experienced engineers — no job is too large or too unusual.

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for any Process, Product or Production

THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R. R. *Salem - Ohio*

Use "Dag" Dispersions...the Really Effective Hot Metal Working Lubricants

Use **"dag"** colloidal graphite dispersions to lubricate under all conditions of extruding, deep piercing, forging, stretch forming, wire-drawing and ingot stripping... to assist in the parting of castings... to provide a lubricant that is impervious to degreasing agents... to lubricate permanently parts that may be subject to extremely high temperatures.

"Dag" dispersions protect against heat ... fatigue failures ... heavy loads... in short, *protect against all the causes of wear.* At virtually any temperature experienced in hot-metal work **"dag"** colloidal graphite overcomes friction and heat and keeps parts lubricated for action.

DRY FILMS of lubricant formed with **"dag"** dispersions have extremely low coefficients of friction; they resist oxidation and function far above the burning-point of conventional petroleum lubricants.

Dispersions of molybdenum disulfide are now commercially available. Experimental samples will be sent on request.

More data on the advantages of **"dag"** colloidal graphite for metal-working operations are contained in a recent bulletin available on request. Write TODAY for Bulletin No. 426-10H.

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Acheson Colloids Company,

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